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THE ENRICHMENT OF THE HIGH SCHOOL COURSE IN PHYSICS.*

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A leader in education has said: "The education and training afforded by our schools is too greatly influenced by the requirements of college entrance. Thus the majority are unprovided with the most efficient and most useful training for the lives they are to lead. The schools teach facts without practical and useful ends in view and without instruction as to how these facts are to be applied." He says further with reference to the particular school under his charge, which sends eighty per cent of its pupils to college: "There is no alternative. Our efforts must be directed to making as good a preparatory school as the colleges will permit; the ideal secondary school must await a more enlightened age of higher education."

Accepting this as the best statement of the situation that can be made, it is probably wise to work harmoniously with the present order of things while using every effort toward a better order.

Such an association as this can do much toward bringing on that more enlightened age when the relation between the college and secondary school shall be similar to that which now exists between secondary and elementary schools. This will mean that the secondary school will give the pupil what he needs and the college will accept a pupil who has been educated according to his own needs rather than the supposed needs of the college. The needs of high-school pupils are much better understood by high-school teachers than by college professors, and they should determine what should fit them for college. Elementary school teach-

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ers are acknowledged experts upon the educational requirements of their own pupils. They would brook no interference from high-school teachers were it offered. How does it happen that high-school teachers have no professional status? To an outsider it would appear that high-school physics teachers are badly priest ridden, since they have a syllabus made out for them prescribing their work in the minutest detail, and they are themselves the only persons who know how great a misfit this requirement is when applied to the high-school pupil. No other department is so throttled.

Let it be conceded that the high-school teacher's task for the present is both to fit for college and at the same time to make his physics teaching as good as he can in spite of college requirements.

The best plan for accomplishing this result seems to be that which has already been adopted in a few schools, namely, to give first a course in physics planned wholly with reference to the needs of the pupils, and follow this by a brief course intended to present the specific things which will be likely to appear on the college entrance examination papers. The first course is taken by every pupil who can get it on his program. The second is taken only by those who are intending to offer physics for college entrance.

I cannot agree with those who would restrict physics to the select few who are mathematically inclined and have perhaps a technical course in view. Physics appears to me to be a subject which all pupils need. The community are now demanding it for their children. Teachers of other subjects adapt their instruction to the needs of the majority of their pupils. Physics teachers must do likewise.

The college entrance course in physics is too meagre in general information and in the applications of physics to daily experience. If the high-school teacher of English were given a syllabus which directed the teaching of grammar alone without literature, his case would be quite parallel to that of the physics teacher.

The course needs enrichment by the addition of large measures of information. Some teachers with excessive allegiance to the inductive method not only refuse to give information, but also to use simple and direct means of illustration. Why should the

department which has the most interesting and most valuable information—information which bears directly upon the common life and happiness of every one—be so chary of giving it to the pupils. Other departments give information freely, and they take a strong hold upon the pupils, but some teachers of physics appear to conduct the course as though they would say to a pupil: "You may have only such knowledge as you can find out for yourself *first hand.*" Getting knowledge first hand is not an elementary process. Post-graduate students when sifted down to the few candidates for the doctor's degree handle it with indifferent success. No individual, however expert, has by the arduous labors of a lifetime been able to get first hand any considerable amount of knowledge. If we teach high-school pupils that they can acquire knowledge first hand without appeal to authority we are deceiving them and we are in danger of making prigs of them. What goes on in a high-school laboratory is neither *induction* nor *verification.* It is simply an attempt to get a realizing sense of things by coming in contact with them. Without the laboratory the pupils would get only inklings; with the laboratory they get some appreciation of what you are trying to teach them. Without the laboratory they get dazed and tire of the subject; with the laboratory properly conducted they get that taste of physics which makes them want further information with an eagerness which is irresistible. A good deal of information in the field of physics is due them, and the course should be greatly enriched in this direction. High-school pupils are not able to receive information in the brief, formal statements of the text-books. They need prolixity. The statements of principles need to be amplified very much. Tyndall's book of six hundred pages on Heat is more comprehensible to them than the forty or fifty pages of the high-school text-books on the same subject. The reading of articles from books of reference and the current magazines is quite as necessary in physics as in English or history.

It has been the fashion to decry the lecture as a means of teaching physics. This is probably due to the prevailing idea that one must not give information, but must leave everything for the pupil to find out for himself. The skillful teacher, however, conducts his course so that no restraint needs to be put upon either of these processes. The more information he gives

the more he stimulates the self-activity of the pupil, and with a broader understanding of his subject the pupil works more intelligently at his appointed tasks. Davy, Faraday, Tyndall and hosts of others have made good use of lectures.

Lectures illustrated by many experiments skillfully performed and skillfully explained; illustrated by lantern slides, charts and blackboard sketches; illustrated by constant appeal to daily experiences; illustrated by graphic word pictures and the use of analogies—such lectures in the hands of a teacher of science furnish not only information, but several other essential features of instruction not covered by the forty quantitative experiments.

College professors in physics habitually complain that students do not generalize. They may have been trained to experiment accurately, but they do not relate facts. The biographers of Sir Humphrey Davy characterize his investigations as *brilliant.* He reached conclusions in incredibly short time. They speak of his wonderful power of generalization and call it "genius," "insight," "instinct." They speak of his constant use of analogies, of his fertile imagination. These traits have charterized all successful scientists to a greater degree than some of us like to admit. It cannot be the business of certain departments to encourage these things and of others to kill them. The processes of education must be better correlated than that.

Even if all high-school pupils were being trained for original research, it may be claimed for the lecture that it has equal value with laboratory work. Our chief difficulties at the present time, however, arise from this very erroneous idea that they are being so trained. In pursuance of this idea a portion of the college course in physics is crowded into the high school, and together they are intended to lead directly toward graduate courses in research. Since, however, few will follow that course to the end, few are disposed to begin it in the high school. There is no good reason on any ground why methods of research should be linked to high-school instruction. It would be a sad fate if, after fighting hard to get some science into the high school; and having secured the introduction of physics very generally throughout the country; and having forced the majority of pupils out of physics, contrary to their needs and desires, so that you might fit the minority for college; and having introduced into

this college preparatory course, at the suggestion of the college professors, a kind of work so illy adapted to the high-school pupil that it does not even fit him for college, you should at last be discredited as educators and some other subject put in the place forfeited by physics. Yet this, we hear on every hand, is upon us unless some radical change occurs soon.

The kind of physics which enabled us to win the fight for introduction into the high-school course twenty years ago was that which was well represented by the first edition of Gage's Elements. For fifteen years that sort of physics made exceedingly good progress in the high schools. It undoubtedly had much to do with bringing on public interest in scientific matters. But in spite of the fact that public interest in physics is still on the increase, we have, inside the schools, turned the tide against physics and are slowly driving the pupils from the subject. I cannot believe that the public, whose interest in the schools is also on the increase, will long permit this state of affairs to exist.

I believe that high-school physics should be the study of phenomena and physical principles should be taught solely for the purpose of explaining the phenomena. Learning principles should not be the end of any study. Formulas, definitions and laws are misplaced and misused. They do not belong at the beginning, but at the end of the subject. They are the crystallized forms of statement useful to engineers and others who have digested the principles and need them in that shape for ready reference. They are also useful for those who are going up for examinations, for which purpose they are best crammed the night before. It would be a waste of energy to carry them throughout the course. The text-book should be more than a dictionary of physical principles and a glossary of physical terms. It should be a book of information written in a readable style. It will serve its purpose better if it leaves all descriptions of experiments and problems to the laboratory manual. The criticism, therefore, that a text-book is not sufficiently quantitative or does not pursue the induction method should be irrelevant. These things belong to the laboratory manual.

The forty quantitative experiments can be very much abridged and lose nothing either in educational value or in effective preparation for college. Quantitative problems upon data given might

very well take the place of many of them. These could be worked out at home just as the problems in algebra are. If physics is to hold its own among the other high-school studies more home work must be devised for it and it must absorb more of the daily attention of the pupil. When physics is made easy and interesting there is often a large compensation in voluntary outside effort. Unless we are sure that we are sufficiently wise doctors in education to safely prescribe a dietary distasteful to the pupils, it would seem to be better to give them bread than a stone, because their appetites demand it. They receive more, they work over it more diligently and they digest it better. We might let them have more of electricity and not compel them to take so much of mechanics. They might spend less time on electrical measurements and none at all on measurements from a battery cell. They might omit the calibration of a thermometer and "double weighing" with the balance.

A quantitative experiment or problem should be the goal toward which several qualitative experiments, or perhaps personal experiences, point. To illustrate: The kitchen stove cools off more quickly than the hot-water tank. A teaspoon taken out of a cup of tea cools quickly, but a teaspoonful of tea does not cool quickly. The sand on the seashore both heats more quickly and cools more quickly than the water in the sea. A few teaspoons taken out of hot water and put into cold water will convey very much less heat than an equal weight of the hot water added to the cold water. Bodies of water modify climate by giving out large stores of heat in cold weather and absorbing large stores of heat in hot weather. Thus it happens that islands in the sea and lakes on the mainland have equable climates. High-school pupils are familiar with these facts, but they have not related them. When they have been led to do this it adds much to their appreciation of the whole matter to determine the specific heat of some substance by a quantitative experiment, and, if the quatitative experiment is allowed, say, one-quarter of the time spent in the study of specific heat, it may be the cream of the whole matter, but if it is the only thing taught under specific heat, it is pretty nearly valueless.

High-school pupils come to the study of physics with a large number of experiences which bear upon the subject, but their experiences have been largely of the unconscious type. If there-

fore "science is merely organized common sense," the teacher must call up these experiences and organize them. In this matter the teacher who deals with country pupils is thought to have the advantage, since country pupils are reputed to have had more experiences in the line of physics, but let us consider what the city has to offer.

A well-equipped city school building contains many applications of physical principles:

The furnace and boiler.

Direct and indirect heating systems.

Ventilation.

Automatic control of temperature.

Steam used for power.

Hydraulic and electric elevators.

The plumbing of the building.

Filters.

The lighting of the building.

Electric motors.

Electric bells, telephones and clocks.

The piano, illustrating the various principles of sound.

A great variety of machines which are superior to the laboratory apparatus for purposes of instruction.

Some pupils have observed these things and thought much about them, others have noticed them but thought little about them, and still others have neither noticed nor thought of them. Excursions about the building will enable the teacher to supply to all some of the necessary experiences upon which to found his instruction, which will take the form of correlating and interpreting these experiences in the light of physical principles.

The home, and the city outside of the school building, are full of the applications of physics. The citizen must square his life according to physical principles whether he wishes to or not. It is our privilege and duty to conduct this study so as to enable him in some measure to make his life more peaceful and more successful.

GENERAL AIMS AND METHODS OF THE HIGH SCHOOL COURSE IN ZOOLOGY.*

By J. Gladden Hutton,
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Before the organization of a course in zoology for the high school, it is necessary to determine just what it is to do for the pupil—to discover wherein the chief gain to the pupil lies. Is it in information, mental training or interest in animals?

It is my duty to propose an answer to this question. Were I able to do this satisfactorily to all persons concerned, I should be able to harmonize conflicting claims made by men who are authorities in the field of zoology. However, I shall reply to this question, as well as to others which may be considered in this paper, from the standpoint of the high-school teacher, whose duty it is to give to the multitude of high-school pupils the best possible instruction to fit them for entrance into higher schools or for entrance into the world of industry without further preparation.

The emphasis placed upon each of the three possible ends of the work as mentioned above can not be determined by the teacher arbitrarily, but it is determined by the relation of the pupil to the great mass of zoological facts, and the relation of this group to other similar groups of facts.

The ideal position of the individual, so far as zoology is concerned, is at the center of gravity of zoological matter. My meaning will be plain if all zoological facts are thought of as being distributed over a plane surface, in which surface the individual occupies a point. He should be so located that the relative distance of the various facts from him varies inversely as their relative importance to him. This arrangement would place him near the important facts around which the science is organized and far away from the facts which are relatively of little importance. This is as it should be, and such a condition may be realized if the proper emphasis is placed upon each fact as it is presented to the pupil. The amount of emphasis should vary directly as the importance of the fact to the pupil.

I think that I am safe in saying that all instruction in the high school should have in view two things, viz., to give the pupil

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information and to give him mental training so that he may have the power of obtaining further information. It should give the pupil tools and the power to use them—the one without the other being practically useless. These two things may be accomplished in presenting the subject of zoology to high-school pupils. Certainly the information gained by the pupil in performing the work prescribed in the course is of great value to him as a factor in the biological world, and there is no course given in the high school which offers better opportunities for mental training. It is necessary that the work be adapted to the needs of those pupils who leave school when high-school work is finished, as well as to those who pursue the subject further in college or university. This may be accomplished by choosing for presentation the fundamental zoological facts and eliminating a large number of minor importance. The aim is to fix in mind these landmarks so that the individual may be able to orient himself in a general way, at least, in the zoological field at any time, for the actual number of facts which he learns in a year's work in zoology is very small when compared with the number which will present themselves in the years to come.

With these fundamental facts well grounded in the mind of the individual, it is necessary that he should have the power to use them and thus be able to master new facts which present themselves to him. Here arises the need of a special mental training which will enable him to proceed scientifically. Further, since zoology may be considered a typical science, the method employed in studying it will apply in the study of all other sciences, and, most important of all, this same method is employed wherever facts are to be classified.

The work in zoology should so train the mind of the pupil that he is able to trace the same principle through a variety of forms in which, perhaps, a development into more highly differentiated forms occurs. This, I believe, is one of the great accomplishments of an educated mind. Interest in animals will come with interest in the subject, and appears as a means, not as an end.

In other sciences and in other fields the pupil must discover an organizing principle when it manifests itself in a variety of forms, and, having performed this process, he may go further and create in his own mind a fact in which the manifestation of a

principle is partly or entirely new. This is the constructive imagination of the inventor and of the man of affairs who sees the end of a great enterprise from the beginning. It is the power of analysis reversed, resulting in that synthetic process which makes growth and development possible. From this point of view it is clear that ultimately the greatest gain to the pupil is in mental training.

It may be said that this is beyond the reach of the high school, yet I know that the beginnings may be made in the high-school classes and that they may serve as a basis for further work in the university without alteration, or that they may serve as a basis for the mental activities of the individual who goes out into the business world without further preparation.

How may this be accomplished? How is the high-school teacher to proceed in order that he may give to the individuals in his charge valuable information and at the same time give them that scientific training which is so fundamental? Permit me to introduce an example from another field. The principle involved in a simple machine is not difficult of understanding even to the uneducated mind, but to understand the principle involved in a complicated machine like one of the improved printing presses used in printing our large daily papers is quite another proposition. Yet the same principle is involved in the complex machine which is involved in the simple machine, though it requires the mind of a trained mechanic to understand it fully. To those who saw the exhibit at St. Louis illustrating the evolution of the locomotive from the primitive form to the latest improved giant of iron and steel it is clear that there has been a growth, a development, from the simple to the more complex, and there must be a growth in the mind of the observer who sees in the complex machine the same principle which is involved in the simple one. This growth is similar to the growth in the minds of the inventors who applied the principle and improved upon the application until we have the product to-day. This power to discover the organizing principle of any group of facts is all important in this complex life of the twentieth century.

Examine one of the simpler forms of animal life and find there embodied certain principles or fundamental characteristics—irritability, contractility, growth, variation, reproduction. Compare this animal with a highly differentiated animal and these

first principles are obscured by the complexity of the organism. Yet the same principles are involved in the higher organism that are involved in the lower form, and the mind with the proper training will comprehend them just as fully as it does in the simpler organism.

This power may be acquired by tracing the development through a number of forms ranging from the lower to the higher in the order of their complexity. To do this it is necessary to study carefully and in detail at least a few representative forms selected from a small number of important groups. The following are suggested, though they may be varied both as to number and kind as circumstances may warrant: Amoeba, Paramoecium, Fresh-water Sponge, Hydra, Starfish, Sea Urchin, Earth Worm, Crayfish, Locust, Moth, Spider, Clam, Fish, Frog, Snake, Pigeon and Rat.

If the pupil's work covers a large number of forms, but only in a superficial way, it is doubtful if those deeper principles, the manifestation of which gives rise to the animal world, will be discovered. The pupil in this way will have a little information concerning a large number of animals, but will not have fixed in mind those important facts around which the science of zoology is organized.

The science of zoology has been divided in three parts, viz., morphology, physiology and ecology. It is difficult to say at this point which should receive most attention, and especially since men of high standing have written text-books for high schools in which varying degrees of importance are given to these divisions. To teach one without the other two would be to teach the triangle with two sides absent. However, one side must be drawn before the other two can be constructed. In a similar way we may consider one division of the science of zoology as a base, a foundation for the other two. Structure appeals to the pupil as something tangible, something permanent. This makes structure a good starting point. A study of structure without regard to function or adaptation to environment is of little value. In every case the pupil should endeavor to discover the function as well as the relation to the environment. Often special adaptations are present and these emphasize development. The real significance of the structures will not be fully understood until they are seen as parts of a living animal engaged in the struggle for existence.

I believe this work in morphology to be of the greatest importance in the study of zoology.

The pupil should study internal anatomy, for it is in the various systems of the body that the fundamental modifications are most evident. These can be studied only by studying the internal anatomy. At this point I wish to say that as much attention as possible should be given to the manner of reproduction and to the fundamental facts of embryology along with the life history of the forms under consideration. I do not mean that a pupil should go into minute details, for this is impossible; but there are certain facts which may be presented which will serve as a basis for future work.

The instructor should teach the pupils to make dissections. The fact that the pupil separates the parts with his own hands gives him the opportunity of gaining information through another sense, thus giving added content to his idea. Demonstrations by the instructor before the class, as well as work with the individual pupil in the laboratory, will beget the careful and thoughtful examination and investigation which are all important in the study of zoology as well as of other subjects.

A permanent record of all work done in the laboratory and the field should be kept, so that any fact observed may be brought up for consideration or comparison at any time. This record consists of notes and drawings which should be completed while the animal is before the pupil, lest the truth should be perverted by a vivid imagination. The drawings should be made from the animal and not from drawings contained in texts, though these latter are often helpful in making clear the more obscure points.

The drawings should be simple and unimportant details should be omitted, thus emphasizing the important parts of the structure. Often the development of an organ may be traced through a number of forms and drawings should show this development. Drawings of the various systems of some of the forms should be made separately. They should not be dismissed from mind until by drawing or diagram the relation of the various systems to each other in the body has been shown. I believe that diagrams are helpful, because they emphasize the important relations of a set of structures and exclude all the unimportant.

All drawings should be accompanied by the proper labels. These are more satisfactory if they appear on a separate sheet

and reference is made by figures or letters. This method leaves the drawing free from writing, an advantage which does not require any comment.

The aim of the course should determine the kind of drawings to be made, and I think that it is clear from the foregoing statements just what the pupil should do in the way of drawings and how he should do it. Clearness and strict adherence to the fact are indispensable. Every line should mean something. In Agassiz's laboratory, which stood on Penekese Island, a class of students, a number of whom have become noted as biologists, worked with this great naturalist. On the walls were a few mottoes, for Agassiz believed in mottoes. One of these now hangs in the Marine Biological Laboratory at Wood's Hole, Mass. Agassiz realized the value of drawing to the scientist when he placed this motto before his students: "The pencil is the best of eyes."

TO WHAT EXTENT IS A CLOSER CORRELATION OF THE DIFFERENT BRANCHES OF COLLEGE MATHEMATICS DESIRABLE FROM THE TEACHER'S STANDPOINT.*

By W. H. Wilson,

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Considering the vital point at issue as brought out in recent papers suggested by the Perry movement, I feel justified in making the term "college mathematics" include both pure and applied mathematics. The teacher's desire is, of course, what he believes will best equip the student for the kind of mental activity in which he will be engaged.

Most of the students of the present day who study college mathematics do not do so primarily for its own peculiar mental discipline. It is becoming more and more evident that a majority of those who are now electing courses of pure mathematics, do so because they desire equipment for specific kinds of work in departments where higher mathematics is indispensable.

The condition was different, at least in the middle West, a

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generation ago. Few of our college, or scientific, men pursued scientific or engineering work to a point where they made any use of calculus. The available courses were limited. The student with vigorous reasoning powers pursued higher mathematics as a kind of mental gymnastics and was satisfied with the general culture and power received. In a majority of cases he made no direct use of the results. The changed attitude here referred to is due to two causes:

First, the development of the profession of engineering, which to-day is so inviting to the young man, has been quite rapid. The engineer and the scientist are both finding higher mathematics to be an important part of his necessary equipment, which he must not only possess, but which he must know how to use with ease in getting reliable results.

Second, other courses have been so multiplied that the student who does not expect to use higher mathematics, in most cases, finds other courses more inviting, and, if well chosen, more profitable.

The result has not been a loss of prestige to the department of mathematics, except in the minds of instructors who have clung to old ideals in the face of radically changed conditions. I do not pretend to say that the pursuit of the higher forms of abstract mathematics, where the specialist reaches conclusions which he himself cannot connect with anything real, much less with any form of practical utility, shall be abandoned. Non-Euclidean geometry possesses little of human interest and is easily set aside as a recreation for the specialist. It would not be surprising if, some time in some way entirely unforseen, abstract studies in higher mathematics such as non-Euclidean geometry should become useful. Greater surprises have occurred in the realm of science. That time is not yet. Undergraduate courses have little if any room for such. If they were offered they would usually lack undergraduate students. Graduate courses have almost the entire field here.

This development in modern education is a very natural one, and is rather to be invited than deplored. It is the business of the mathematician to touch as many points of human interest as it is possible for him to touch. If we are quick to seize the opportunity a larger field of usefulness awaits us. One of the noblest characters I ever knew had as her motto "I serve." She lived in

accordance with her motto, too, but there was nothing in this attitude of mind which detracted from her dignity, and certainly not from her worth.

Let us look a little into the methods by which we are to meet these conditions. Much should be done before the student enters college, but the responsibility rests no less heavily upon the college teacher, for in most cases he trains the teacher who trains the entering collegian. Throughout his mathematical studies the student's theories should be connected in a vital way with the other fields of his mental activity, and, if necessary to the accomplishment of this end, the pruning knife must be applied till the more productive branches have room to develop and bring their fruit to a fuller maturity. Not only will the tree be more healthy and beautiful, but the fruit will be more appetizing as well as more nourishing.

Graphic methods not only lead the student naturally into exact measurement, and into the processes of mechanical drawing, but they also give a more comprehensive as well as a detailed view of the relations studied, because they utilize the experienced visual sense. Graphical methods also place the best possible check on the analytic processes.

In talking with a student of a leading technical school I was surprised to learn the extent to which they depend upon graphics in practical work where considerable precision is necessary. The student must always have the analytic method in reserve, but the necessity of its constant use is relieved by drawing to scale. My attention was first called to the possibilities of mechanical drawing in a very forcible way a few years ago. A friend of mine, who is a manufacturer and an inventor, had designed a new model for the mould-board of a plow. He had no technical knowledge of mathematics, not even of the names of the trigonometric ratios; yet he had chosen a geometric surface which I had never met in my work. He employed me to help him get such command of the surface that he might be able to meet certain conditions. In technical language the problem was so to modify the parameters of the surface as to accomplish a desired end. I attacked the problem in accordance with my training by the analytic method. The equation of the surface was easily gotten. The plan of operation was easily outlined. But the computations which I deemed necessary were very laborious. After several days of pretty hard

work I showed him my results. It was impossible to carry him through my work, so I simply gave him the results with specific directions how to accomplish results within the limited range of my computation. He accepted my work and listened to my explanation of some of the geometric properties of the surface. On the following day I called to make some additional explanations. To my astonishment he had, by robbing his time for sleep, taken up the matter, from my explanations, entirely independently of my computations, and had graphically solved the problem in a very simple way with an accuracy far beyond his needs. You may be sure I never forgot the lesson.

Teachers of college mathematics and their colleagues in the secondary schools ought to agree upon a line of action which will result in a thorough unification of the analytic with the graphic, applied to problems borrowed from some fields of science or art, in the mathematics of all secondary schools. Drawing to scale will often give a student control over an analytic situation which otherwise he would grasp only partially if at all. The time allotted to mathematics need not be increased. Sufficient time could be gained by removing from our mathematical courses some of the rubbish which has accumulated from past ages. The result would be that students entering college would be at home from the very start in the methods which the practical scientist and engineer must have.

What, then, shall the teacher of college mathematics do under the improved conditions here outlined? The correlation here sought is not to be found in some internal bond of union, but in that application to the things of real human interest, which cause the student to lose sight of the exact classification of the processes in his eagerness to reach the conclusion not simply for its own sake, but for its bearing on some investigation the data for which come from some source other than a fertile imagination.

The most effective means of the desired correlation are to be sought in the mind of the instructor. He must, of course, have a training in pure mathematics much beyond the subject he is trying to teach, in order that he may guide the student along the lines of least resistance and greatest utility. He must draw aside the veil here and there and display vistas which the student may glance at in their proper relations, but must not enter at the time. The instructor must not only have this advanced training in pure

mathematics, but he must be at home in the more important branches of applied mathematics, in order that he may draw upon them for illustrations and carry on investigations with an appreciation of the exact bearings of his mathematical conclusions. I firmly believe that he should have at least one hobby in applied mathematics in the riding of which he may get that exercise which makes him virile and interested in human affairs. Surely by following such a course an instructor is in a better position to help the present day student than if he were to spend all his spare time in the regions of the fourth or *nth* dimension, or in non-Euclidean space of any kind.

Moreover, the college instructor in mathematics must be ever ready to adjust himself to conditions as he finds them. He cannot afford to wait till he finds his students prepared to his ideal. He must introduce the methods in which he finds his students lacking, if he allows them to enter his classes, even if he finds it necessary to reduce the amount of work he might otherwise do. He must suggest lines of application and require actual work in applying the principles as they come up. In the very short lived journal, School Mathematics, there appeared a definition: "Mathematics is that science in which you do not know what it is you are talking about and you do not care whether what you say about it is true." Doubtless this definition was first given as a joke, and, of course, it was repeated as such, but it meets a pretty hearty response in the mind of the college man who was required, without adequate preparation, to take some courses in mathematics, which should have been elective, under an instructor who did not know much besides mathematics and hence was not a good teacher of mathematics.

In the following suggestions of a more specific character I shall deal only with methods which I have actually tried with some good results.

In college algebra I find many entering freshmen who have the ordinary preparation but know nothing about graphs. The time is well spent in teaching how to plot both linear and quadratic equations, both for the purpose of showing the general nature of functional relations and also for showing the correlation between intersections and the simultaneous values of the variables gotten by elimination. He may also understand why in some cases he gets some values which do not have corresponding inter-

sections. Complex numbers are seen to correspond to no intersection. The plotting of complex numbers by the conventional method does not make them any more real, yet it serves the purpose of showing how real, complex and pure imaginary numbers are correlated, and ultimately leads to a more effective way of dealing with the theory of equations. If only it were possible, complex numbers might well remain out of sight; but they are always turning up in connection with equations of the second and higher degrees, and it is surely best to reduce them to an orderly classification rather than to leave them lying around where they will be stumbling blocks. They are unmanageable creatures, to say the least, but since we are obliged to associate with them, it is best to get on good terms with them as soon as possible. After all, some good things may be said about them.

Before beginning the subject of chance last year I asked each of my algebra students to get four coins and make eighty throws of these coins and record the number of times they got 4 heads, 3 heads, 2 heads, 1 head, no heads. They were given no suggestion that one of these results was more likely than another. Some individual results were surprisingly discordant with theory. I averaged the results by fives taken at random, showing that these averages agreed with each other much more nearly than did the individual results. I then took the average of the first averages. Of course, most of the students caught the reasons for the results which we found, and could state them in a very intelligent way. Some could even figure out the exact theory. The closeness of the final average with the theory was a lesson in the canceling of accidental errors in the long run. Their interest was aroused and their perception sharpened for the further study of chance and choice.

In trigonometry the field for drawing to scale and choosing practical problems is very fertile. Problems made up of actual data accumulated by the surveying class in connection with familiar objects about the campus, always arouse interest and help the student to understand how this study is useful. A frame made from four strips of wood fastened together with a specially made set screw may be used to show how the functions vary with the angle, by making the angle and the triangle, from which the functions are defined, actually grow through all of the quadrants. The triangle will vanish as one of its sides passes through 0, re-

appear in the next quadrant in a position which is seen to fit the original definition. A symmetrical diagram with four general statements enables the student to stow away in available form all the relations among the different functions of a single angle with no real effort to memorize. Of course this diagram must not be allowed to usurp the place of a proof any more than do Napier's rules in spherical trigonometry. But the general statements and the diagram appeal to the visual sense of symmetry, which is not only interested and pleased, but renders effective aid in future work. The Walter Smith school square No. 2 is part of the outfit of each of my students in trigonometry. It is made of heavy cardboard distinctly printed, with the means of measuring angles and tenths of inches, and is sufficiently accurate for drawing rectilinear figures to scale. It can easily be sold for 10 cents, and is the best thing for the purpose I have seen.

Spherical trigonometry can be applied to finding distance and direction to some point on the earth's surface which is attracting attention at the time. The only data needed are the latitude and longitude of the places. A few simple astronomical problems, such as the time and place of sunrise at a given time of year at a given latitude, are easily understood. The student will grasp eagerly at the task of working out the specifications for a sun dial to suit a given set of conditions.

Calculus is the paradise for the application of mathematical principles to things of interest to the student. In integral calculus conclusions follow each other in rapid succession, which if allowed to go unapplied will soon disappoint the student. In differential calculus the ingenuity of the instructor is sometimes taxed to show applications, but his efforts if properly directed never fail to attract interest. Of course, there is the whole field of maxima and minima values of functions with indefinite application to natural phenomena, but even here the full advantage of the situation is not always utilized. In the standard problem of the maximum contents of a box made from a rectangular piece of cardboard much valuable information may be brought out as to the way in which the truth of an equation applies to material things. The edge of the square cut out is naturally made the independent variable. When the graph is constructed it shows nicely the maximum value, but it also shows that only a small range of actual values of the independent variable will give a

material box, while the requirements of the rest of the locus are inconsistent with the properties of matter and so do not represent a real box. Yet all the quantities are real.

With the object of showing how processes may be simplified I usually ask my students in differential calculus to develop a series of antitangents whose sum equals $\frac{\pi}{4}$ so chosen that they converge rapidly and with easy calculation. Then we actually work out the value of π to 20 decimal places, making a careful arrangement of the work to facilitate comparison. The work is pleasingly easy compared with the method suggested in most geometries, but rarely followed out even to six correct decimal places. The work would scarcely be doubled if carried out to 40 places. The student thus learns the power of the instrument he is learning to use, and also gets drill in the actual carrying out of a complicated plan to a definite conclusion with several means of facilitating computation learned along the way.

I often take up a study of the catenary curve in the midst of differential calculus. It is easy to show from a few simple principles of mechanics how the differential equations are obtained. A little anticipation of the work of integration introduces that subject under favorable auspices. The student grasps the application readily and easily and is pleased with the results. He sees the practical application to suspension bridge work, and realizes that he has found a new method of getting the equation of a curve and its length. He is easily shown that if the origin of coordinates be properly chosen the ordinates will be the measure of the tension to which the cable is subjected at any point per unit of weight in a unit of length of the cable.

As before intimated, integral calculus is full of possibilities of the most interesting and practical character when viewed from the standpoint of the student of science or engineering. I cannot dwell on details here. I usually end my elementary course in integral calculus with a consideration of force and consequent motion. The force of gravitation varying according to Newton's law is chosen. The differential equations are easily derived and the integrations easy, and the complicated formula of planetary motion are easily reached, and are always full of interest. As the student comes to the realization that the formulae for falling bodies are merely the forms which these equations assume when

the acceleration is made equal to the constant g, he is not only pleased to come back to earth, but is well satisfied with his tour of investigation into the regions of space.

One text book in calculus which I used, for one year only, made what I consider the grave error of concerning itself with putting all the proofs in such a form as to make them impregnable to any attack now and forever. The object in itself was a worthy one, but the sacrifice was too great and the goal scarcely reached. The students did not appreciate the difficulties and consequently did not appreciate the manner of avoiding them. In most cases their work did not carry them into the region of the difficulty. Consequently the process seemed to them like putting up men of straw for the purpose of vanquishing them. It seemed to me like introducing the principles of the higher criticism to Sunday school scholars. It is sometimes best to call the student's attention to some point of attack which he may sometime be called upon to strengthen, but that he will do well to accept the results of others at that point till he has wider experience in the application of his subject.

And now, in answer to the direct question of my subject, I wish to say that many think the pendulum is swinging to the extreme in these matters.

There is danger that the bright student who sees at a flash the entire application of his results and who will feel unnecessarily restrained if obliged to go through the details of graphing and applying his equations too often. For others the available time is usually so limited that it becomes an individual question how to direct the mathematical work of each student so as to get the maximum result of mathematical training which shall be available for use in after life.

AN EASY METHOD OF CLEANING MERCURY.

By B. W. Peet,
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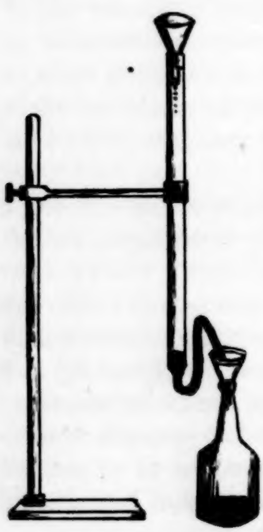
Many methods have been proposed for cleaning mercury, but they are usually more or less complex or the simple methods are not definitely described. The following method suggested by Ostwald is simple and efficient:

Place the dirty mercury in a bottle and shake with dilute sulphuric acid, to which from time to time add a few drops of potassium dichromate; then wash with a large volume of water, until the water on being decanted is perfectly clear; separate as much as possible of the water decantation, transfer to a separatory funnel and remove the rest of the water. If no separatory funnel is available remove as much as possible of the water with a pipette, transfer to an evaporating dish and dry with filter paper or by heating.



Arrange an apparatus like the figure, which consists of a bottle, two funnels, filter paper and a long glass tube about fifteen millimeters in diameter, having a smaller bent tube sealed on one end. An ordinary burette could be used, the bent tube being connected by means of rubber tubing. Nearly fill the tube with a dilute solution of mercurous nitrate to which has been added a little nitric acid. Punch a very small hole in the apex of the filter paper in the funnel at the top of the tube in order that the mercury may drop through the solution in a very fine spray. The clean mercury flows out of the end of the bent tube and is finally dried by allowing it to pass through a pinhole in the apex of a folded filter paper in the funnel and thence into the stock bottle. This leaves the mercury very bright and ready for ordinary uses. If the mercury is not very dirty all that is necessary is to allow it to drop through the acid solution of mercurous nitrate. A very desirable method for distilling mercury is given by Hulett in School Science, Vol. I., page 426.

ON THE IMPORTANCE OF THE NUMERICAL EXERCISE IN TEACHING GEOMETRY.

By Arthur Schultze.
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The importance of the numerical exercise is one of the strongest illustrations of the fact that the logical and the pedagogical treatment of geometry are by no means identical. For the logical representations of geometry, numerical representations are entirely unnecessary, in fact text-books exist which do not make the slightest reference to numerical work. For the purpose of presenting the subject to young students, however, the numerical exercise is an absolute necessity. It is one of the best, if not the best means, of correlating the unknown with the known, and of representing abstract generalizations in a concrete manner. It interests the student on account of its practical utility and frequently supplies material for exercise work, when no other can be obtained.

The student who begins geometry and studies the definitions of lines and angles has no geometrical knowledge which could form material for exercise work, but the need of exercises to familiarize him with these new concepts is exceedingly pressing. In fact a large percentage of the failures in geometrical study are due to imperfect understanding and assimilation of the geometrical concepts. Together with geometrical drawing, numerical work meets this want in a very satisfactory manner. Let the student find the numerical value of the angles formed by the hands of a clock at different times, or assign a numerical or literal value to one of the four angles formed by two intersecting straight lines and require the value of the other angles. Let five lines radiate from a point either forming equal angles or with numerical values assigned to four of the angles thus formed. Ask for the values of the angles formed by three intersecting lines if two of them are known, etc. Finally deduce some general geometrical truths by means of numerical relations. Bisect two supplementary adjacent angles, and assigning a numerical value to one of them, find the angle formed by the two bisectors. Although the students at this stage of the work do not know what a theorem is, many of them will see that the answer 90° is general and not at all dependent upon the numerical or literal value

selected for the first angle. Similarly erect perpendiculars upon the sides of an angle at the vertex in different directions, and find relations either numerically or algebraically between the resulting and the original angle. Every new definition of any importance should be made so familiar to the student that its meaning can always be recalled without mental effort, and frequently, even in advanced work, the numerical exercise is the best that can be employed for the purpose, as e. g. for the explanation of similarity or for the definitions relating to proportions.

But it is not the definition alone that needs explanation by concrete illustrations, frequently the meaning of a proposition is not at all clear to some students until interpreted by numerical exercises. The sentence, "Similar triangles are to each other as the squares of their homologous sides," and the corresponding algebraic symbols, should be made perfectly clear by numerical applications, as e. g. the finding of the numerical ratio of the area of two similar triangles whose sides are known, or the finding of the sides of a triangle, similar to one whose sides are numerically known, and whose area bears a certain ratio to the required one. Especially theorems expressing proportionality need that explanation, since there is always a tendency to lose sight of the real meaning of algebraic symbols and to handle them in a mechanical way.

The explanation of the meanings of the propositions is, however, only a function of secondary importance; far more important is the fact that numerical examples may be used to teach the method of applying propositions and of using them as tools. If numerical applications can be formed—and they can be formed for 50% of all theorems—they should form the first group of applications for each proposition, since their great simplicity and concreteness brings them within the reach of almost every student. In this manner we may prove that lines are parallel, the numerical values of certain angles being known; we may prove that triangles are scalene, isosceles or equilateral, if two angles are known or can be found; we may find the values of angles when their sides are intersected by a circumference and certain arcs are known; or we may find the length of a line if it is a side of a pair of similar triangles and certain other lines are known, etc., etc. There is hardly a chapter in geometry that does not offer opportunity for work of this kind, and the formation of

such exercises is usually a very simple matter. As it is impossible in a brief paper even to enumerate all chapters for which such illustrations can be found, only one more class will be discussed, namely those propositions that express a numerical relation and are studied chiefly for the purpose of finding numerical values. The majority of the propositions of Book III are of such nature. The value of the proposition, "The product of two sides of a triangle is equal to the altitude upon the third side, multiplied by the diameter of the circumscribed circle," rests upon the fact that it establishes a numerical relation between four quantities and makes possible the finding of one of them, e. g. diameter of circumscribed circle, when the other three are known.

It is not an unusual practice in many schools to develop from the general propositions formulae for the median, bisector, altitude of a triangle, etc., and to solve numerical exercises solely by reference to these formulae. This method, however, can hardly be recommended, for first, it increases the number of formulae to be memorized, second, it fails to impress upon the student's mind sufficiently the fact that in every equation one quantity can be found if the others are given, and that an equation containing four unknown quantities contains the solution of four problems. Another evil in developing the formula without preceding numerical problems lies in the difficulty of making students discover some of these formulae. It is somewhat difficult for the average student to find the formula for the altitude of a triangle, even in its simplest, unfactored form. The difficulty, however, will be greatly lessened if the different steps are clothed in arithmetical form. For example, the three sides of a triangle are 13, 14 and 15, to find the projection of 15 upon 14 offers no difficulty if proposed in connection with the proper theorem. After the student has had sufficient practice in this exercise he will readily find the altitude numerically and finally also algebraically. By work of this character the student is made to see clearly what is really essential to the solution; he can, if necessary, reconstruct the formula, or can solve a numerical exercise without the formula. While there is good reason for requiring a student to know finally the altitude formula in its factored form, there is absolutely no reason for making the same requirement in case of a median, a bisector, the diameter of a circumcircle, etc.

In a manner corresponding to the derivation of formulae, nu-

merical work can frequently be used to derive new theorems and their proofs. To many students the proposition relating to the square of the side of a triangle opposite an acute angle is rather difficult, while it loses all perplexity if proposed within a series of properly graded exercises. Propose various arithmetical and algebraical applications of the Pythagorean Theorem. Let the base and leg of an isoceles triangle be given, first numerically, then algebraically, and require the value of the altitude, or propose a similar question for the equilateral triangle. Try to discover the base of a triangle if its two other sides and altitude are given. Ask for the third side if two sides and the altitude upon one of them be known. Assign numerical value to two sides of a triangle and to the projection of one of them upon the other, and require the third side, and finally propose the same question in an algebraical form. There will be many students who easily follow such a series of exercises and thereby derive a lasting understanding of the propositions. To give an example of a construction simplified by numerical work, consider the problem; "To construct a square which shall be to a given square as *m* is to *n*, etc." Propose it at first as follows: Construct a square equivalent to 3/5 of a given square, and if this should be difficult, let the student draw a rectangle equivalent to 3/5 of the given square, and finally ask him to transform the rectangle into a square. Almost any class of students will be able to discover the construction if proposed in this form.

There is a whole group of propositions which yield much more readily to arithmetical treatment than to any other method of attack, namely, those which establish relations between angles. If we wish to prove that the angle formed by a bisector and an altitude drawn from the same vertex of the triangle is equal to the difference of the two non-corresponding angles of the triangle, the beginner finds it pretty difficult to discover a purely geometrical proof, and even the algebraical demonstration which is usually given, cannot always be discovered by the majority of students. The matter is, however, greatly simplified, if, at first, numerical values are assigned to the two angles, and the student is requested to find successively the numerical values of the other angles of the diagram, until the angle formed by the altitude and bisector is obtained. One or two numerical examples are usually

sufficient to enable the student to discover the algebraical proof for this and many similar theorems.

It is hardly necessary to discuss the mensuration problems, which usualy make up Book IV and the greater part of solid geometry, for the practical importance of numerical examples illustrating these chapters is so evident that probably all teachers give sufficient emphasis to this phase of the work. It is advisable in all kinds of numerical work to select examples which do not contain great arithmetical difficulties, for the object of such work is the study of geometry and not the study of arithmetic, and a difficulty utterly foreign to the subject diverts the student's mind from the geometrical aspect of the question. For the same reason the notation for algebraical work should, in most cases, be made as simple as possible, e. g., lines should be denoted by single letters.

In conclusion it may be well to state that it is of course not necessary to use a large amount of numerical work in every class and for every grade of students. It is the student hampered by a lack of mathematical ability, by immaturity, or by poor preparation, to whom numerical applications furnish material for simple original work, that could not be provided by other methods.

The various uses of the numerical theorems may be summarized as follows:

(1) For the explanation of definitions.

(2) For the explanation of the meaning of propositions.

(3) For the construction of simple applications of the propositions.

(4) For the discovery of new theorems and their proofs, and also for representing proofs in the simplest manner.

(5) For the practical value of the results, as e. g., in mensuration.

Sources of Radium. In a report from Mr. Joseph I. Brittain, United States consul at Kehl, Germany, it is stated that the slime or residuum of the thermal springs of the city of Baden-Baden, Germany, contains considerable quantities of radium salts. Professor H. Gertel, of Wolfenbüttel, says that the radium compound extracted from these deposits is forty times more powerful than that found in the residuum of cold-water springs or in mud baths. Hertofore these deposits have been considered worthless, but they are now carefully collected and sent away for treatment. These baths have for a hundred years had the reputation of possessing healing qualities.—*Electrical Review.*

A SIMPLE EXPERIMENT ON THE COOLING OF AIR BY EXPANSION.

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The teaching value of an experiment in physics is much greater if the experiment is so simple and direct as to need no apparatus for its performance, and especially if it be one which the student can easily repeat for himself. The commonest method of illustrating the fall in temperature of a gas during adiabatic expansion, i. e., change of volume without addition or extraction of heat, is that in which the mist is shown which forms in moist air under the receiver of an air pump with the first few strokes of the piston. This cooling effect is now used on such a large scale to produce artificial refrigeration in cold storage warehouses and elsewhere, that a simpler experiment illustrating the fact should be welcome.

Such an experiment is the following: Holding the lips tightly shut, bring the root of the tongue into contact with the palate so as to enclose in the mouth as large a volume of air as is practicable. This air should now be compressed as much as possible by muscular action of the tongue and cheeks. The mouth is then to be opened and the air gently forced out. As the moist air in the mouth passes out, expanding as it does so, it is sufficiently chilled by this expansion to form a quite dense mist, which the experimenter can readily see himself, and which is easily seen by every one in the class room if the experimenter stands between the pupils and a window. It will probably be found easier to compress the air to the required degree if the fingers are held tightly pressed against the lips. It should be understood that the compression is to be carried out entirely in the mouth, the connection to the lungs being cut off by the tongue, for the pressure which can be produced by the muscles of the cheeks is much greater than that which can be obtained by a contraction of the chest.

Some people find difficulty in succeeding with this experiment; to such the following modification is recommended: Pour a few cubic centimeters of water into a large glass flask, and shake it about in the flask so as to thoroughly saturate the enclosed air with vapor. Now place the mouth of the flask tightly against the lips and alternately compress and rarefy the air in the flask by

aid of the muscles of the cheeks and tongue. If this is done with sufficient vigor a fog will form in the flask at each exhaustion. In this form the experiment is quite easy, but the addition of even so simple a piece of apparatus as a flask causes it to lose some of the charm of simplicity.

THE TRUE FIELD OF PREVENTIVE MEDICINE.

By Wilfred H. Manwaring, M. D.,
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The most powerful factor of modern civilization is public opinion. It determines legislation, blocks reform, directs economic movements. And nowhere is its influence more evident than in movements affecting public health. Desirable measures in this direction are prevented and existing laws made inoperative through it.

Popular ideas of medical facts, therefore, constitute the greatest factor in the world-fight against disease. And popular ideas are often wrong. The literary woman who "does not believe in germs," the teacher who denies the very existence of disease, the preacher who thinks vaccination "against the Gospels," the merchant whose strength is in his "electric" belt, and the lawyer whose ten-drops-before-meals controls a cancer, are typical. What can be expected of such a society but opposition to measures requiring honest and intelligent coöperation?

The preventive medicine of the future must therefore concern itself with popular knowledge. It must determine what medical facts will be of greatest value to the people, and how these facts can be gotten before them.

The most valuable facts are the fundamental facts regarding the nature of disease. Given these, and measures to combat disease follow logically. While hygenic laws, taught without these facts, are often open to doubt and misinterpretation.

The main agencies for the diffusion of such knowledge are the public press, the public lecture and the public school. Of these, the press is of least value. It is filled with pseudo-science, superstition and deception. People are not trained to separate its truths from its falsehoods, and are equally credulous and skeptical of both.

The public lecture is little better. The public school, however, is of great value. It has no ulterior motives. It speaks with authority. It speaks at a time when facts may be brought to the understanding and made of most value. To the public school, then, we must look for the ultimate solution of the problems of preventive medicine. The teacher is the real soldier in the world-fight against disease.

The public school has done little in the past in this direction. Legislation has attempted to stimulate effort, but the medical ignorance of teachers has defeated its purpose. Opportunities must be given teachers to become familiar with the fundamental facts of bacteriology and pathology before they can successfully undertake this work. And boards of education must realize the great importance of such teaching, before it can be efficacious.

Just what should be done in the public school remains to be determined. The high school, however, seems logically to be the most efficient point of attack, and the introduction of a laboratory course in bacteriology the surest stimulus to further efforts. The high school is a training school for elementary teachers. It is the main preparatory school for college, and the finishing school for the majority of educated citizens. Proper instruction here would therefore be far-reaching in its effects.

When medical instruction receives half the effort in secondary schools now given the study of bones of dead civilizations, and when the teacher of hygiene is as well prepared in his subject as are the teachers of physics and chemistry today, the improvement in the health and reduction of the death-rate of the country will be very great. From results already produced one can safely predict that in the United States alone an annual saving of a quarter of a million lives, and an annual increase in wage-earning capacity of a billion dollars, can be brought about by this means.

The educational movement against disease is therefore a movement of great economic as well as great social importance.

LABORATORY WORK IN PHYSICAL GEOGRAPHY.*

By Herbert C. Wood,
East High School, Cleveland, Ohio.

Within the last ten years the teaching of physical geography in the larger high schools has been so changed that it amounts to a revolution. This revolution has been so complete that it seems hardly possible that it can have taken place in so short a time; and it is doubtful if the next decade will see further radical changes in principle. Changes there will surely be, but they will not be in the fundamental principles, which now seem to be pretty well established. They will consist in a settling down to a more uniform expression in the larger schools and to an extension of both principles and expression into the smaller schools.

It is worthy of note that the revolution has required much less time than did that in chemistry or physics which preceded it and which had been fairly accomplished before that in physical geography began.

If we consider the era of laboratory work in high school physics to have begun in 1880, which is the date named by Mr. A. P. Gage in his "Introduction to Physical Science," we may consider the era of laboratory work in physical geography in high schools to have begun fifteen years later, or in 1895. About that time it was started in New England.

In 1900 the first physical geography laboratory in a high school west of the Allegheny mountains was opened in the East High School of Cleveland. Some laboratory work was begun by the writer in the Central High School in 1895, but there was no apparatus or material especially provided for it. It consisted of a study of common rocks and minerals with specimens gathered from monument works and by excursions into the surrounding country.

When the three new high schools were built in this city, and the first one completed, in 1900, rooms were fitted up and everything needful was provided for modern physical geography laboratories. The rooms in the older buildings were also remodeled and provided with suitable outfits for laboratory work.

The progress of laboratory work in all schools where it has been introduced has been guided largely by the text books which

* Read before the Northeastern Ohio Association of Science and Mathematics Teachers, Feb. 11, 1905.

have been published since 1895; and its introduction into more schools has been coincident with or closely following that of such authors as Davis, Tarr, Gilbert and Brigham and Dryer.

The adoption of a modern text book is a comparatively easy matter, provided the school board is amenable to reason; and so is the equipment of a laboratory, if it is fairly liberal with its money. On the latter score it is not unfair to say that a first class physical geography laboratory can be equipped for about one-fourth the cost of an equally efficient chemical or physical laboratory.

The number of expensive pieces of apparatus is small, and this does not include any that are required for pupils' individual work. They belong more properly to the work of demonstration by the teacher, and only one of each kind is required. The Gardner's season apparatus is of this kind. Other pieces, such as the projection lantern, the mercurial barometer, a whirling table, thermometers, and other pieces of chemical and physical apparatus may be considered the common property of the entire science department of the school. Therefore, to use them to teach physical geography is but to increase their value.

The United States Government is the most liberal government in the world, when it comes to providing material for studying geography. For further information I have but to refer you to the lists of publications of the Geological Survey, the Coast Survey, the Weather Bureau, and other departments.

A great deal of material that is valuable can be collected by teacher and pupils, and many simple devices can be made which cost very little. It needs only a teacher with an eye to preserving them to collect quite a store from successive classes. Physical geography requires almost no perishable material; and, if we reckon the cost of what is worn out in the service as it should be reckoned, i. e., in terms per capita of the pupils benefited, that cost becomes absurdly small.

But, to return to the more vital question of the laboratory work itself, we may take it for granted that we have a room fairly well suited to our needs and a stock of material with which we are reasonably satisfied and address ourselves to the problem of what we are to do with them.

Without presuming to give a solution which will commend itself to everybody or which would be practicable in all schools,

I will state first the general policy of laboratory work in the East High School and then describe some of the specific exercises.

The course in geography is a one-year course of 45-minute periods per week. It is given to second-year pupils in the scientific course. It is optional with manual training, so that not all pupils in the scientific course take it nor do any in the college course.

We are required to prepare for a final examination in June and we are expected to complete the text book, Davis's Physical Geography. No double periods are provided for laboratory work, so that not more than 45 minutes are available on any one day.

The amount of laboratory work in a year is determined by the time required to complete the text book. Some time must also be allowed for lecture and demonstration work, examinations, and reviews. At a rough estimate, this leaves 20 per cent of all the time for laboratory work. This permits of about 25 distinct exercises, although more than that number of periods is required, because some of the exercises are continued if they are not completed in a single period. This division of time seems reasonable, and it has worked well in practice.

The five exercises are in mathematical geography, four of them being in map projection.

The first exercise is suggested by the text book. It consists of drawing an ellipse with the true scale of the earth's orbit. The exercise is first explained and directions are given. The pupils do most of the mechanical work at home, but complete it in the laboratory on the following day. The exercise is correlated with the change of seasons as explained in the text book. The Gardner's season apparatus is introduced at this point; and, by means of the slated globe which belongs to it, the problem is worked out inductively.

Each pupil then obtains at home a piece of cardboard in which he cuts a hole 6 inches in diameter. A 6-inch pasteboard globe is furnished to him in the laboratory, and this, with his cardboard and the drawing of the orbit in his note book, is the apparatus for the next day's work.

By placing the cardboard over the globe, he can locate the day and night circle; and, by moving the globe around the orbit, he works out for himself the problems of the change of seasons and of the varying inequality of the day and night throughout the year.

The definitions of perihelion, aphelion, equinox, solstice, and ecliptic come in incidentally, but so naturally and obviously that they seem almost to teach themselves.

Of course the pupils make innumerable blunders and they have to be watched closely; but they finally work their way out, and the effectiveness of the exercise is proved by the fact that this subject doesn't have to be taught again to that class.

The four exercises on map projection I shall not describe in detail. They have been completed by this year's class, and the work may be seen in the note books exhibited here.

In meteorology we do not make formal observations for record. This is done in some schools and it is undoubtedly of value, but we have omitted it for several reasons. We have a reliable record in the daily newspaper; and, on account of the ventilation of the building by a forced draught, we cannot open the window in front of the instrument box without that draught affecting the thermometers before they can be read. The only other place for the box would be on the roof of the building, and that is not accessible to pupils. Then too, school is not in session on Saturdays and Sundays, so that if a record were to be complete, someone would have to come to the building to make observations on those days. All the instruments are explained, however, and the pupils handle them, the anemometer excepted, as we do not have one.

The barometer affords a good chance for practical work with both mercurial and aneroid forms. After construction of the mercurial barometer and the method of reading it have been explained, each pupil is required to make a reading to the hundredth of an inch. This includes setting the mercury to zero and adjusting the vernier. Printed instructions are posted near the barometer, and he may practice as much as he pleases beforehand. This exercise arouses a great deal of interest; and many pupils continue to make readings and watch the daily changes after they have done the required work.

Daily weather maps are sent to the school by the local weather bureau and these are displayed in the laboratory throughout the year. All the maps are preserved; and, when the class is ready to study them, each pupil is given one as his own. He uses this map, and more if necessary, in his laboratory work.

This work consists, first, of marking the arrows showing wind direction heavily with a pencil about the high and low

pressure areas, so that the whirls are distinctly shown. Then barometric "gradients" are drawn from "highs" to "lows," and the relation of wind movement to air pressure is determined.

The pupils are required to learn the "Wind and Barometer Indications," as printed on the map, as an introduction to some of the simpler principles of weather forecasting. The origin and progress of storm centers is explained, and selected maps showing strongly developed warm and cold waves are displayed in the laboratory.

Constant effort is made to establish a familiar relation between the local weather and the general atmospheric conditions shown on the map on any day—that is, to teach the pupils to interpret the weather in terms of the map.

The teacher has preserved several series of weather maps, each series covering a period of five or six days, and these are used to explain the successions of weather changes which are typical of different seasons of the year.

For a few weeks at this time, we take about ten minutes each Monday morning to study the six maps of the preceding week as a series, while the actual weather experienced is still fresh in our memories, and to compare the forecasts with the data of the map.

We also have a complete series of the maps issued by the Washington office covering a period of nine months. These maps are larger and more elaborate than the local maps.

About half the laboratory work is on land forms. We begin with a careful study of the technical features of a topographic map. No particular region is selected, but several maps showing typical areas of plains, plateaus, mountains, glaciated regions, and shore lines are first given to each pupil.

He is required to study thoroughly the printed matter on the back of one sheet which is alike for all and to verify the explanations by reference to all the sheets before him. He thus makes himself familiar with the fundamental idea of representing relief by contours, the contour intervals used for different kinds of land surfaces, and the varying horizontal scales of different sheets. He is then ready to begin a more specific study of sheets selected as types of the many kinds of land forms. We have found the folios of the Topographic Atlas, No. 1 and No. 2, very helpful, especially in getting pupils started upon this work. The descriptions of the

regions selected are excellent models of composition; and the pupils make abstracts of them in their note books.

After a sheet of the Atlas has been studied, loose sheets of similar regions elswhere are provided from a collection of about 2,000 sheets. These are in sets of 30, 15, and 10, according as 1, 2, or 3 sheets of a type region are obtainable, so that a whole class may work upon the same topic at one time.

When three or more adjacent sheets are available, the pupils at one table can match their sheets at the edges so as to make a large map for studying a more extended area. This is particularly effective for studying the larger features of a region, such as those of the Appalachian ridges, or of the extended coast line of New Jersey.

Greater care and more watching are necessary in this work with the topographic maps than in any other part of the laboratory work. It offers more opportunities to the indolent pupil to "soldier" and to the mischievous one to experiment in pastures new.

There is one thing, however, which will set all to work with a definite purpose. That is the composition; and in this lies the gist of all the work with topographic maps.

The pupil must learn not only to *look,* he must *see;* and, when he has seen, he must learn to *tell* what he has seen. He must do this, too, in the language of a geographer.

He will find this hard at first, and for several reasons. His power to see those features of a particular map sheet which are characteristic of the region and which are essential to his description must be developed. His vocabulary must be greatly enlarged and must include words and phrases which are peculiar to geography. His description must be comprehensive and, at the same time, logical, progressive, and concise.

This seems like expecting a great deal; and yet, I think that any teacher who has not tried it will be surprised at the power which these young people will acquire with a little well directed practice.

A well written text book, not too narrow in its scope, with a stock of technical words and phrases well selected and distributed, is more than ever necessary to furnish a fund of ideas upon which the pupils may draw. The Atlases are more specific and may serve as a more direct guide in particular cases, though care must be taken not simply to paraphrase their descriptions but to follow their broader lines of initiative, sequence, and inference.

The laboratory course is concluded with a half dozen exercises upon rocks and minerals. The purpose of them is simply to make the pupils familiar with the common kinds of rocks which they see in the field and used as building materials, and which the text book names as composing the earth's crust. A simple classification of rocks as aqueous, igneous, matamorphic, and organic, with a few subdivisions for convenience is given, but a complete genetic classification is not attempted.

The minerals are treated chiefly in their function of forming rocks and in their relations to weathering, decay, and soil making The pupils have not studied chemistry or physics, so that we touch rather lightly upon chemical composition and crystallography. The acid test for limestone is explained and demonstrated; and, if time permits, some determinations of specific gravity are made.

Our collection includes a genetic collection of rocks, a collection illustrating some common geological phenomena, such as faulting, jointing, crumpling, lamination, glaciation, and volcanic products, a collection of rock-making minerals, and an economic collection which includes building stones, coal, and metallic ores.

The exercises with the rocks and minerals arouse more interest than any others in the course, but just why I have been unable fully to determine. Perhaps it is because the pupils come into closer touch with the things they are studying than when they are working with the diagrams, globes, models, maps, and printed descriptions of earth forms. The natural beauty of good specimens and the possibilities of many substances hitherto unfamiliar seem to appeal to their practical natures and to make interesting a subject once thought to be rather dry and hard.

As a final test, I have sometimes required each pupil to identify ten specimens which I would pick up at random from among about two hundred; and I flatter myself that it was more than a guessing contest, because I required each one to give the reasons for the faith that was in him.

I do not feel that laboratory work in geography is yet established upon a basis at all to be compared with that upon which chemistry and physics now seem to be pretty well settled in the best high schools; nor is it to be expected that such should be the case. Those subjects have about fifteen years the start of us, and we can only hope that when we have had twenty-five years' experience we may have our main lines equally well established.

At present there is no well defined agreement among teachers of geography as to the amount of laboratory work that should be done; and still less is there agreement as to just what things should be done. This want of a general agreement is not due to antagonistic opinions nor to a lack of common ideals; but rather is it to be accounted for by the great diversity of conditions among the schools, such as the length of the geography course, the examinations required, and the facilities provided for doing laboratory work.

A few colleges now give credit in physical geography as one of the optional subjects which may be presented by a candidate for admission. Harvard and the University of Michigan thus recognize it. The scientific schools give it a somewhat more important place in their requirements, but do not insist upon it. For example, Case School of Applied Science names it among its requirements, but allows high school graduates to substitute manual training for it. Neither colleges nor scientific schools put physical geography upon the same basis with chemistry, physics, mathematics, or language; but, in so far as they do accept it, laboratory work, with properly certified note books, is insisted upon as a part of the requirement. The College Entrance Examination Board so specifies, as do Harvard and Michigan.

Undoubtedly the time is coming when a candidate for admission to a college course in liberal arts will be expected to qualify in something more than Latin, Greek, mathematics, English, and history; and we may expect that sometime there will be a "Committee of Ten" appointed by the National Educational Association to formulate as definite a requirement in physical geography as they have in physics.

Meanwhile, the teachers of this subject must work out, each in his own way, a scheme of laboratory work that will be comprehensive, and practicable. A large body of matter is before them to be worked over; but, when these teachers get togteher in this Central Association and in others in different parts of the country, the results will be crystallized into a body of exercises which will be accepted as a standard of high school work and of college entrance requirement.

POND, STREAM OR LAKE, AS A STIMULUS TO MORE PRACTICAL WORK IN BIOLOGY AND PHYSIOGRAPHY.

By R. W. Sharpe.

Instructor in Science, New Trier Township High School, Cook County, Illinois.

The characteristic tendency of secondary school science of to-day is to lay greater stress on obtaining knowledge at first hand. In fact, though on a smaller scale and in a way fitted to the comprehension of younger students, we are attempting to do what the colleges will ask of the same students at a later day.

That this is a sane method of obtaining information seems beyond cavil. The person who must gather all his information at second hand from some other source or authority, is likely to be badly misled at some time or other, not to speak of the lack of independence which he must experience all through life. While a great amount of our information may—probably must—be derived from books, yet there must be a background of personal experience to make the information gained of real worth. All teachers experience great difficulty with younger pupils, with their almost exclusively bookish education, in getting them to realize what the study of the thing itself is, or means. They are quite ready, in a parrot-like fashion, to repeat whatever may be given in text-books, or what has been told them, yet to form their own ideas from the real thing is a bug-a-boo indeed.

Educational authorities have of late years begun to realize all this, and the laboratory idea is just now being entertained with unusual seriousness by school boards of this and other states. Where formerly classes in physics, chemistry and biology did little more than memoriter recitation work from text-books, we now find some sort of provision made for genuine contact with nature, if little more than an improvised shed where the pupils gather together to study the results of a foraging expedition.

Amusing, yet how instructive, the early struggles of scientists in developing the laboratory idea! Up to the middle of the 17th century little real progress had been made, principally because of the lack of an organized body of scientists, where the attrition of like minds, making suggestions to each other, criticising, comparing and reasoning, might act as a stimulus to a productive

intellectual activity. This element was introduced by the organization of the Royal Society of London and the Academy of Sciences of Paris.

That the embryonic investigators of these societies had troubles of their own is amusingly illustrated by the following instances: One inquiry was sent all the way to Batavia, to know "whether there be a hill in Sumatra which burneth continually, and a fountain which runneth pure balsam." Another, to this country, was concerning the stupefying herb Datura, "whether the Indians make it lie several days, months or years, according as they will, in a man's body, without doing him any harm, and at the end kill him without missing an hour's time." Another was "whether there be a tree in Mexico that yields water, wine, vinegar, milk, honey, wax, thread and needles."

Of historical interest is the work of Robert Hooke, about the middle of the 17th century, where he appeared before the Royal Society of London and obtained the affidavits of its members to the effect that they had really seen certain small animals in a drop of water—animals that we now call protozoans.

But enough of this. The spectacle of Agassiz at Penikese is still before us, and all that remains is to provide the time in our school programs and furnish proper leaders and we will have pupils genuinely enthusiastic over the study of their surroundings. At the same time just enough of the commercial spirit of the age should be injected into their work as may lead them, as well as their parents, to feel that they are really accomplishing something of far reaching value, other than learning the scientific names of some insects, trees or flowers, or perchance becoming familiar with methods of dissection and the technology of the microscope.

Permit me to say, in this connection, that I know of no more active and enthusiastic workers along this line than Doctors Forbes, Burrill and Davenport, of our own State University. Their publications regarding the fauna and flora of the state are exceedingly helpful and suggestive, and just now the Illinois State Laboratory of Natural History is sending out to the high schools of the state named collections of Illinois insects of economic importance, accompanied by a brief manual of the more interesting facts concerning them. A genuine interest is being awakened, and even the rural schools are being reached with a

reviving spirit which is truly remarkable. Agricultural clubs are being formed and farm breeding contests are being entered into with enthusiasm and profit. In fact, it seems to me that we of the high schools may well profit by a study and imitation of the methods used in some of our rural schools along these lines. Personally, I believe the time has come when all, even the smaller of our high schools, should offer a year's course in scientific agriculture, closely correlated with physiography and biology—the immediate surroundings being the subject matter of study.

To quote Thomson in his "Study of Animal Life," "We do not want to know all that is contained, even in Chambers' Encyclopedia, though we wish to gain the power of understanding, realizing and enjoying the various aspects of the world around us. We do not wish brains laden with chemistry and physics, astronomy and geology, botany and zoölogy and other sciences, though we would have our eyes lightened so that we may see into the heart of things, our brains cleared so that we may understand what is known and unknown when we are brought naturally in the face of problems, and our emotions purified so that we may feel more and more fully the joy of life." Perhaps another familiar quotation may be permitted here: "A circuitous course of study followed with natural eagerness, will lead to better results than the most logical of programs if that take no root in the life of the student." Indeed, in the latter part of this statement lies my excuse for the quotation. Encourage and broaden the practical interest, and it naturally becomes geographical and physiographical, leading up to the natural history of the region being surveyed. This seems little but common sense, yet we seem to realize but little how important this may be to the boy or girl, who has most likely never been able to conceive of a really intelligent interest of any certain subject under discussion, but is familiar with it only "a memoriter."

In endeavoring to carry out these ideas, no better subject for teacher and students can be found than the immediate neighborhood of the school itself, especially as there are but few such neighborhoods that do not afford a pond, garden, small lake or stream for special study. Here is a source of work for all the different departments of the school—its study will afford opportunity for the English department, the mathematics department and even the history department. Our pond or stream must be measured,

its shape determined and mapped, its position, depth, and other peculiarities made out; this, of course, implies noting the facts, writing them down, thinking about them, and finally writing out the full account. The class in physiography may well take care of the temperature observations, noting the rainfall, snow, frost, clouds, winds and storms. The classes in biology will be interested in finding out the kinds of animals and plants inhabiting the region or growing on its banks, noting their habits, numbers, distribution and feeding habits. It is becoming more and more of a truism that what the students in our schools need more than anything else is experience and practice in seeing things as they really are. It is difficult to conceive how any school could possibly offer training of any more value than that to be obtained by patiently observing the phenomena of its own surroundings.

To quote an eminent authority, Dr. B. W. Evermann, now with the United States Fish Commission, "A child taught to study his surroundings will be really educated; he will have had eight to twelve years of actual doing, instead of that number of years of parrot work and lifeless memorizing that the schools are now giving. He will be self-reliant; will know the value of evidence and the little value of authority; will possess real knowledge instead of book misinformation; moreover, he has learned to do by doing and knows how to do things. There is little danger of a child so educated ever falling a prey to any of the frauds or fallacies at the present time so prevalent in this country."

An outline somewhat similar to the following, which has been adopted from one used by the United States Fish Commission, might very readily be made to do service, and if carried throughout a period of time, say not less than a year, the results would be a real contribution to knowledge, well worth publishing in the local papers, and even in popular and scientific periodicals.

The outline here given is very briefly suggested, and for convenience is subdivided into the physical features and the biological features of any small local area, such as a pond, stream or lake—the one being the special work of the classes in physiography, the other of the classes in zoology and botany.

PHYSICAL FEATURES.

a. Geographic position.

1. Size, form, length and width, length of shore line.

2. Hydrography: average depth, topography of bottom, stages of water.

3. Character of shores: low or high, sandy, gravelly, rocky or marshy.

4. Catchment basin: extent, general character, wooded or other vegetation.

5. Inlets: character and extent, as to direction, volume, etc., outlet.

6. Bottom: whether of mud, sand, gravel, rock, muck, marl, etc.

7. Meteorology: amount of precipitation and evaporation, time and character of rains, winds, sky, air, temperature, etc.

8. Character of water, chemical and physical, including purity, hardness, character and source of impurities, clearness, etc.

9. Observations daily of temperature of water at surface, bottom, etc.

10. Phenomena connected with the formation of ice, when it forms, maximum thickness, air holes and their relation to life in the pond, etc.

b. BIOLOGICAL FEATURES.

I. Zoological.

1. Plankton.—Species of protozoa or other small forms of animal life entering into the plankton of the pond, showing vertical and horizontal distribution, abundance at different seasons, effect of rains, winds, temperature, etc.; relation to other animal life of the pond.

2. Crustaceans.—Species, abundance, distribution, value, etc.

3. Mollusks.—Same as with crustaceans.

4. Similar observations and information concerning the species of the various other groups of aquatic animals occurring in the pond, including the turtles, batrachians, worms, insects, etc.

5. Fishes.—Abundance, distribution, feeding habits, etc.

6. Mammals.—List of those found about the pond, paying special attention to those living in or about the water; their habits, whether they feed upon fishes, mollusks or other aquatic animals.

7. Birds.—The species found about the pond, including the permanent residents, summer residents, spring and fall migrants and winter visitants, paying special attention to the water birds; time of arrival of each species in the spring, how long they remain, when they return in the fall and how long they stay; feeding

habits, especially of the ducks, grebes, herons, kingfishers, and the like; influence of water birds in keeping open places in the ice during winter.

8. Odonata, lepidoptera, and other insects about the pond whose larvae may appear in the water; mosquito larvae, etc.

II. Botanical.

1. Aquatic vegetation. *a.* Fixed species—List of species growing in fixed position in the water, abundance, distribution and life history of each; time of their first appearance in the spring, flowering, fruiting, and disappearance in the fall; shade and other protective values; relation of aquatic vegetation to absorbed gases in the water.

2. Plankton.—Algae and other plants, both vertical and horizontal distribution, abundance at different seasons, etc., as with the animals.

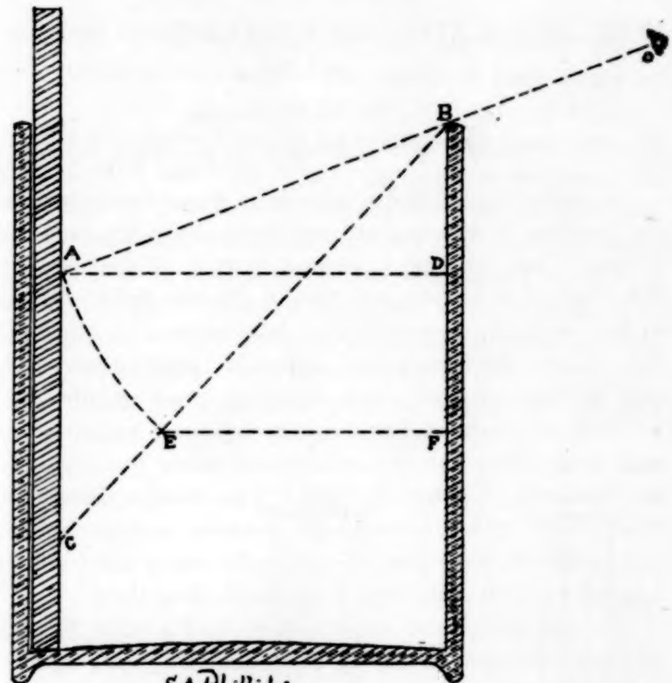
3. Marsh species.

4. Shore vegetation.

A SIMPLE METHOD OF DETERMINING THE INDEX OF REFRACTION OF LIGHT FROM WATER INTO AIR.

By George B. Masslick.
John Marshall High School, Chicago.

Place a measuring stick in a battery jar, or other glass vessel with perpendicular sides, upright against one side. Note the interior height and with another stick determine the distance from the face of the first stick to the opposite side of the jar, the diameter of the available jar, both of these measurements to be within 1 mm. Set the jar on the floor or in a low sink in such a position that another pupil seated or standing can see over one edge of the jar to the stick upright against the farther side of the jar. (The pupil's eye must be somewhat higher than the top of the jar to avoid total reflection.) Note the reading of the line on the stick just visible over the top of the jar. Carefully fill the jar full of water and record the lowest reading *now* visible from the same position. A pen or pencil moved along the stick down into the water will make this reading easier. It should be made with great



care (to 0.1 cm.), as much of the success of the experiment depends upon this. It would be well for the pupil to change his position slightly and repeat the experiment one or more times or for the pupils to exchange places and repeat.

To determine the "index" and record the results draw on coordinate paper a rectangle whose sides are the exact height and diameter of the "available" jar and indicate the two readings on the stick. Lines from these two points to the opposite corner of the rectangle represent respectively the direction of the ray light as it comes to the eye after leaving the water and its direction through the water. The angles which these lines make with the perpendicular to the water surface, that is, the line representing the sides of the jar are respectively the angle of refraction and the vertical angle of the angle of incidence. The values of these angles may be read from a protractor, or better, equal distances may be taken on the two lines from their intersection (for an equal hypoteneuse) and the ratio of the perpendiculars to the line representing the side of the jar be determined.

HOME MADE STORAGE BATTERIES FOR PRACTICAL USE.

By H. R. Brush,
Principal of the Ashland, Ohio, High School.

In many high schools, especially those in the smaller places, the question of an adequate supply of electricity for experimental purposes has become a serious matter. There are also many cases where it is desirable to use electric light or small motors in the incidental work of the laboratory and, during the daylight hours, the commercial system is not in operation. Primary cells at best are costly and annoying; they require the frequent addition of chemicals; the voltage of many varieties is variable; and, lastly, they are not economical when it comes to fulfilling the demands of power or light. The storage battery is the only kind of cell which conveniently permits such utilization and the comparatively high cost of such cells deters most schools, whose laboratory fund is limited, from purchasing them.

Feeling the almost imperative need of a daily, plentiful supply of electricity for laboratory purposes, two years ago I began to contemplate the construction of a home made set of batteries. It was with some misgivings that I did so, as I felt some doubt about the reliability of home made storage batteries and their durability when made. I dismissed the Planté type because of the time required for formation of the plates and concluded to make them of the packed style. Our set of batteries received its initial charge in August, 1903, and since that time has been in continual use for lighting, small power and experimental purposes. It has received no attention since that time with the exception of the closing of the charging switch at night to replenish the supply and the addition of water to replace that lost by evaporation. During all this time the batteries have never failed us and they are at the present date in excellent working order, having suffered only the slight deterioration to which all commercial batteries are subject in time. To construct them took about all the spare time of one person for three weeks, the cost of the material was about fifteen dollars and their actual value was estimated by an engineer to be over one hundred dollars. Such a record has been so markedly successful that it has occurred to me that it might be useful to some of the readers of

SCHOOL SCIENCE AND MATHEMATICS, who can connect with a day, direct current system, to give the details of their construction.

For casting the plates a board one foot square was covered with plaster of paris one inch thick. In this was hollowed out a space three-eighths of an inch deep in the shape of the plate having the dimensions shown in Fig. 1. After this mold had been thoroughly dried by baking, melted block lead was poured into it and five plates cast for each battery. The plates were then taken to a machine shop and, with a sharp drill, 30 half-inch holes were bored in them. (Two plates may conveniently be drilled at once.) After drilling the surfaces were flattened by rolling in a tinner's rollers and the edges smoothed up with a file.

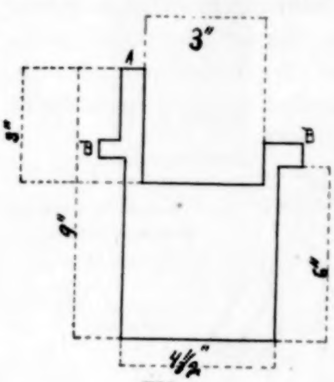


FIG. 1

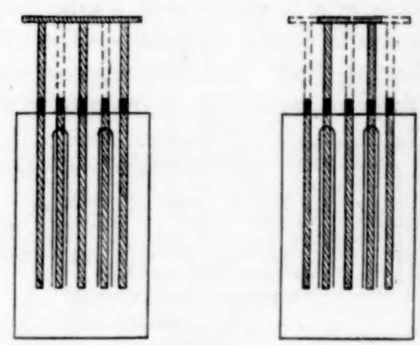


FIG. 2

They are now ready for receiving the paste. Each battery has three negative and two positive plates—the latter placed between the former. The paste for the negative plates consists of of yellow lead oxide or litharge, mixed to the consistency of thick dough with a 10% gravimetric solution of sulphuric acid. The holes in the plates were filled with this paste, the material being pounded in. A little of the dry litharge was sprinkled on the under side to prevent the paste from sticking to the board on which the plate is laid during the process of packing. A No. 16 wire was run through the center of each filled space afterwards to allow free access of the battery fluid. The positive plates are packed in the same manner, except that red lead, or minium is used, instead of the litharge, and a small amount of plaster of paris is added for strength.

The plates are now set away in a warm place until dry and hard and are then assembled in the following manner. Leaden bus bars three inches long are cast; the negative tops (A-Fig. I) are soldered to these bars, leaving the space of an inch between them. In like manner the positive are soldered to other bus bars so that these plates may fit in between the negative plates—the bus bars of the two sets being, of course, at opposite ends, as in Fig. II, which shows the views of the battery from the positive and negative ends.

The glass battery jars may be bought of any dealer in battery supplies or storage battery house. They cost very little. In these jars the plates are placed with the lugs (B-B' Fig. I) resting on the edges. The two sets are insulated from each other by hanging over each positive plate two pieces of glass tubing bent in a U shape, with a hole blown through the center of the curve to permit the air to escape when they are submerged in the battery fluid. The cells are then connected in series by soldering strips of sheet lead to the proper bus bars.

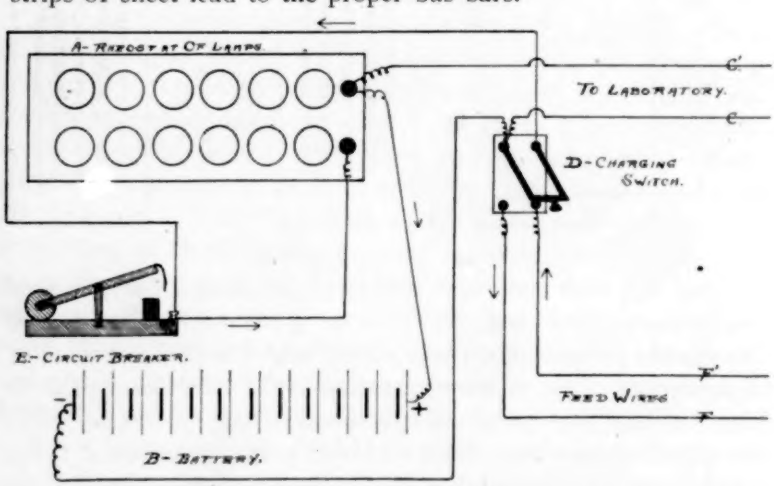


FIG. 3. General Arrangement of Battery, Etc.

The assembled batteries and the devices for charging are shown in detail in Fig. III, which will serve better than a written description. A is a lamp rheostat, made by taking a thoroughly dry hard wood board one inch thick and 30 inches long and eight inches wide and attaching to it twelve sockets such as are used in store windows for fixed lamps. The lamps are, of course,

arranged in parallel. B represents the battery; CC′ the wires from the battery to supply the laboratory; D the charging switch; E the automatic circuit breaker; and FF′ the feed wires from the incandescent system.

The automatic circuit breaker, although not absolutely necessary, is an advisable construction, shown in side elevation in Fig. III, and in detail from above in Fig. IV. The base consists of a

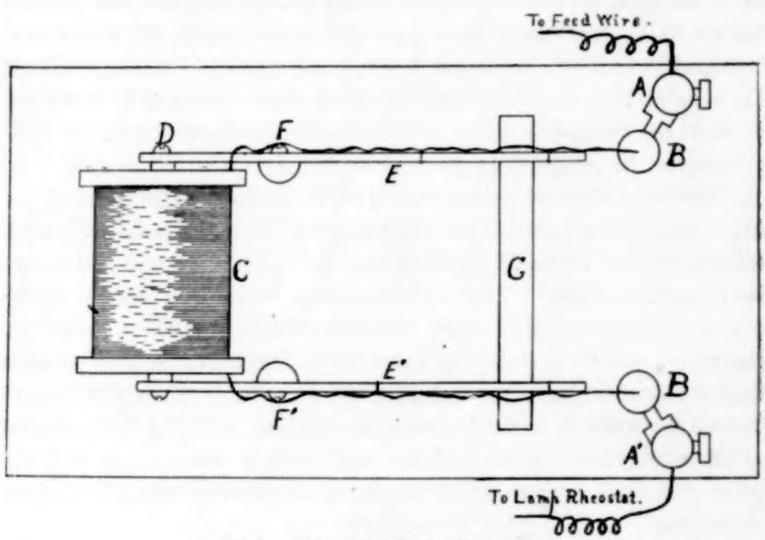


FIG. 4. Detail of Circuit Breaker.

board 6x10 inches of hard wood, well shellaced. A wooden spool, C, 2½ inches long is so pierced as to admit a soft iron rod, D, one-half inch in diameter. Twenty feet of No. 16 double cotton covered magnet wire are wound on C. The ends of D are tapped so as to fasten to them two soft iron strips one-eighth of an inch thick and 7 inches long. These strips are supported by pivots fixed in the upright pieces, FF′, 3 inches in height, which are fixed in the base and so arranged that the whole system works on FF′ as an axis, as shown in Fig. III. G is a soft iron bar one inch square and four inches long, attached to the base. BB′ are two mercury cups bored in the base and filled with mercury. The terminals of the coil on C are brought along the iron strips EE′ and so arranged that they dip into BB′ when C is raised so that the strips EE′ rest on the bar G. A is a binding post connected with one of these cups and with one of the feed wires

and A′ is another post connected with the other cup and with one side of the lamp rheostat as shown in Fig. IV. The mode of operation is briefly this: When the charging switch is closed and C is raised until the ends of the coil dip into the mercury cups BB′, the circuit is completed through the lamp rheostat, the batteries and the coil C. The rod D and the strips EE′ are magnetized and are attracted down to G, holding the circuit closed until the dynamo stops, when D ceases to be a magnet and gravity causes C to fall, thus breaking the circuit. As the battery is charged its voltage rises and lessens the current flowing through C. Then, if a movable lead strip be laid across EE′ between C and the support FF′, a time will come when gravity will neutralize the magnetism and cause the circuit to be broken.

Several points must be observed in charging the battery the first time. The battery acid consists of 30 parts sulphuric acid by weight and 70 parts distilled water. The sulphuric acid must be chemicaly pure. The mixture must be cooled before being placed in the cells and must not be added until all is ready for charging, and then charging must begin immediately and be continued for a series of consecutive periods, aggregating 40 hours before any attempt is made to use the battery. During the process of charging the negative plates turn a dark slate color and the positive a dark brown and these colors are indicative of a normal condition.

The batteries should not be "jolted" by short circuiting and should not be discharged below 1.8 volts each. They can be charged to about 2.4 volts each and a set of 12 cells such as described will deliver a current of 15 amperes at a pressure of about 27 volts for a period of 6 to 8 hours.

To replace water which evaporates, distilled water should be added by means of a thistle tube to the bottom of the jars as the denser sulphuric acid tends to sink to the bottom. A whitish deposit indicates sulphating and should be removed by charging. It is unnecessary to remark that, in charging, the positive wire of the dynamo must be connected to the positive wire of the battery.

There are a number of points which must be learned by experience and information gained in this way is most valuable. Every battery should be frequently and separately tested with a voltmeter. If the voltage is low the cell needs attention, either by cleaning or charging.

DUALISTIC PROPERTIES FOUND IN LINEAR EQUATIONS.

By R. L. Short,
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Now that considerable work in Graphs is being carried on in our high schools, perhaps it may not be out of the way to discuss some properties not usually taken up in connection with such work but which are of great interest to all mathematicians. The writer does not claim any originality for what is set forth in this paper but has tried to present the matter in such a manner as to be easily read by those teachers who have not taken a course in Modern Geometry.

Any one who has done some plotting of curves realizes that any values assigned to x and y fix a point on the curve, i. e.—the x, y are the co-ordinates of a point. Also the position of the curve depends entirely on the co-efficiencies and the absolute term, i. e.—on the constants of the equation. That is the constants of the equation are the co-ordinates of the line.

We shall consider the line $ax+by+c=o$, where the a, x, b, c, y, may be arbitrary contsants or may be variables as we shall direct.

The a, b, c are co-ordinates of the line. If we let $x=x/z$ and $y=y/z$, our equation takes the form

$$ax+by+cz=o,$$

which is homogeneous both in the line co-ordinates and in point co-ordinates.

The equation now has a dualistic property and states: that a point (x, y, z) lies on the line determined by (a, b, c) or that a line (a, b, c) passes through the point determined by (x, y, z).

We will consider in detail what happens if x, y, z vary while a, b, c are constant and what will happen if x, y, z are constant and a, b, c vary.

1. Take a fixed point $(x, y,$ $ax+by+cz=o$ and we will have an infinity of lines, each passing through the point (x, y, z) and we have a pencil of lines. Fig. 1.
continually satisfy the equation $z)$ and let (a, b, c) vary so as to

1a. Take a fixed line (a, b, c) and let (x, y, z) vary so as to *continually satisfy* the equation $ax+by+cz=o$ and we have an infinity of points, each lying on the line determined by (a, b, c), that is we have a point row. Fig. 1a.

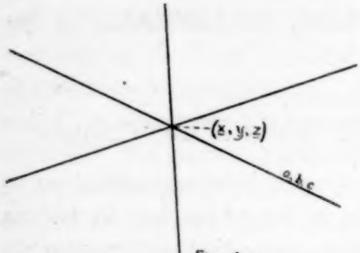

Fig. 1.

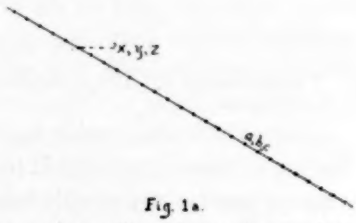

Fig. 1a.

The equation of a point on a line gives also a line through a point.

2. Required that two lines in point co-ordinates $(x, y, z$ vary) go through the same point.

$ax+by+cz=O$

$a'x+b'y+c'z=O$

are the lines. Condition that they pass through the same point is that the x, y, z satisfy both equations at the same time, or that

$x : y : z = (bc' - cb') : (ca' - ac') : (ab' - ba')$

Values of x, y, z, satisfying the first equation give all the points on the line $ax+by+cz=o$. Likewise values satisfying the second equation give all the points on the line

$a'x + b'y + c'z = O$

When one determined value satisfies both equations at the same time, the two lines pass through a common point.

Fig. 2.

2a. Required that two points are on a line.

The points are given in line co-ordinates, i. e. consider (u, v, w) the co-ordinates of the line.

$au + bv + cw = O$, 1st point.

$a'u + b'v + c'w = O$, 2nd point.

The condition that they lie on the same line is that the u, v, w satisfy both equations at the same time or that

$u : v : w = (bc' - cb') : (ca' - ac') : (ab' - ba')$.

Values of u, v, w satisfying the first equation give all the lines through the first point. Likewise all values of u, v, w, satisfying the second equation give all the lines through the second point. When one determined value satisfies both equations at the same time the line joining the two points is determined. Fig. 2a.

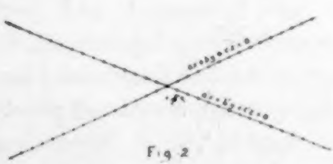

Fig. 2

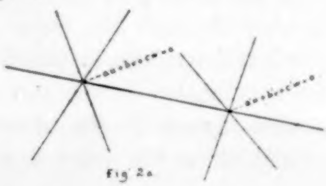

Fig. 2a

3. Take two points x', y' and x'', y'' and seek the line joining them.

(This is the same problem as 1a except that it is in point coördinates).

$ax+by+c=o$ (1) is a line. If the line passes through the point x', y', it becomes

$ax'+by'+c=o$ (2) and if through x'', y'' it is

$$ax''+by''+c=O \quad (3).$$

(2) and (3) are conditional equations and the ratio is

$a : b : c = (y'-y'') : -(x'-x'') : (x'y''-x''y')$

Substituting these values in (1) for a, b, c we have

$$(y'-y'')\,x-(x'-x'')\,y+(x'y''-x''y')=O,$$

the required line. See Fig. 3.

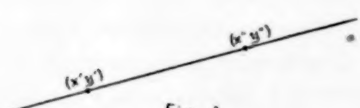

Fig. 3.

Or, taking equations (1), (2) and (3), and eliminating a, b and c, we have

$$\begin{pmatrix} x & y & 1 \\ x' & y' & 1 \\ x'' & y'' & 1 \end{pmatrix}=0$$

which is the same equation.

4. Given two lines in point coördinates to pass a line

3a. Required that two lines determined by u', v', w' and $u'' v'', w''$, pass through a common point,

$au+bv+cw=O$ (1) is a point.

Requiring that u', v', w' and u'', v'', w'' pass through this point, we get two conditional equations

$au'+bv'+cw'=O$ (2)

$au''+bv''+cw''=O$ (3)

Then eliminating a, b and c, as in problem 3, we obtain ratios to substitute in (1), or, using determinant notation, we have the equation

$$\begin{pmatrix} u & v & w \\ u' & v' & w' \\ u'' & v'' & w'' \end{pmatrix}=O.$$

which may be written in the form

$$u\,(v'w''-w'v'')+v\,(w'u''+u'w'')+w\,(u'v''-v'u'')=O.$$

See Fig. 3a.

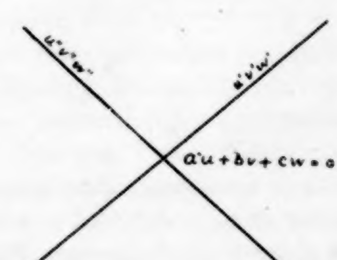

Fig. 3a.

This is the same as problem 2, except that it is stated in line coördinates.

4a. Given two points in line coördinates to find the equa-

through their point of intersection.

$ax+by+c=O$ (1) is a line.
$a'x+b'y+c=O$ (2) is a line.
$(ax+by+c)+$
$k\ (a'x+b'y+c')=O$ (3)
is the required line, where k is an undetermined parameter.

The equation is of the first degree and therefore represents a line. It is satisfied for all values of x and y which satisfy both expressions in parenthesis, and therefore it passes through the intersection of the given lines. When k remains undetermined we have a pencil of lines.

See Fig. 4.

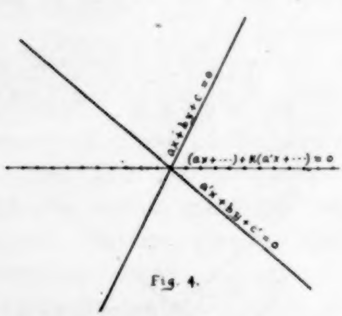

Fig. 4.

tion of a point on the line joining them.

$au+bv+cw=O$ (1) is a point.

$a'u+b'v+c'w=O$ (2) is a point.

$(au+bv+cw)+$
$k\ (a'u+b'v+c'w)=O$ (3)
is the required point, where k is an arbitrary parameter.

The equation is a point because linear in u, v, w. It is satisfied for all values of u, v, w, which satisfy both expressions in parenthesis, and is therefore on the line joining them.

When k remains undetermined (3) is satisfied for any point on this line and we have a point row.

See Fig 4a.

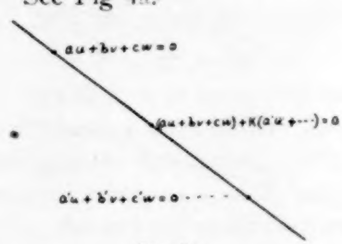

Fig. 4a.

The homogeneous equations used in this paper may all be reduced to the usual form in two co-ordinates by dividing through by z, or by substituting $z=1$. The original equation might also be used in place of the line co-ordinate equation introduced in problem 2a. The equation $ax+by+cz=o$ can be made to depend on two variables and two arbitrary constants by dividing it through by cz.

ESSENTIALS OF SUPPLEMENTAL EDUCATION WITH REFERENCE TO SCIENCE TEACHING.*

By Walter M. Wood,
Superintendent of Education, the Young Men's Christian Association of Chicago.

The whole field of education may be divided into three divisions as follows:

First—Fundamental Education—preparing one by general or professional training for entrance upon his life work. This service is the peculiar work of the schools proper, and is intended to serve those who are of the professionally student class.

Second—Incidental Education, or that which one acquires as he meets the problems and performs the duties of his daily life and work.

Third—Supplemental Education, or that which gives one in the midst of his life of activities that which he has failed to get in the schools, and is now failing to get in active life. This supplemental education is the peculiar work of educational movements other than the schools proper and serves most largely those who are engaged more in other things than in study. Supplemental education is not an imitation of fundamental, nor a substitute for incidental education, but is a means of educational help to those who are under the stress of age and working conditions unfavorable to the most efficient intellectual life. Its motto might be said to be, Give this man what he needs most, next.

Supplemental educational effort finds expression in varied agencies, such as the following: Reading Rooms, Museum Exhibits, Libraries, Reading Courses, Instruction by Correspondence, Directed Conversations or Practical Talks, Educational Lectures, Educational Clubs, Tutoring and Educational Classes, the variety being necessitated by the different needs and educational inclinations of the individuals served. Such work is intended to cover educational delinquencies, to arouse dormant minds, to cultivate sound mental habits, and to keep awake and put to use trained intellects. The key principle underlying it all, in the choice of subject matter, in the method of instruction and in the conditions under which the instruction is given, is *adaptation*

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* Some notes from an address before the Chicago Local Section of the Central Association of Science and Mathematics Teachers.

to the individual case in hand rather than attempted imitation, or rigid requirement of traditional forms and methods sometimes mis-called standard.

Certain educational characteristics of such work are of interest. It deals with two distinct classes of students: (a) Students proper, constituting the small minority who seek with definite student purpose a general education. (b) Non-students, constituting the great majority, who seek by adapted instruction educational help in the solution of some present problem or in fitting for some special service. The work is elective to a maximum degree and is adapted to meet individual and special needs without unnecessarily breaking from recognized educational standards and methods. It is conducted in small and varied units so scheduled that sequential arrangement in courses is possible when desired. It is made to glow with the recreative element in both subject matter and treament. It aims in its more elementary forms at suggestion and inspiration rather than thorough training. It seeks to increase the life-living capacity rather than the scholastic ability of the student.

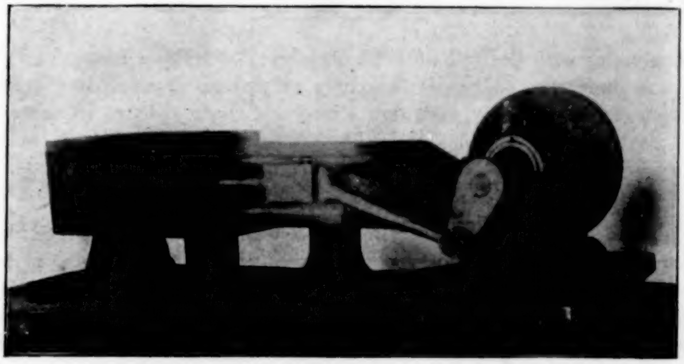
Such work is of interest to teachers of science because of the nature of instruction and leadership required in behalf of evening class students, irregular students in the day schools, those of student habit who are not attached to any school, and those who have never acquired, or have forsaken, the habit of consecutive reading and study. The teaching of science to individuals comprised in the groups named, in the major part is with a view to making science study *a means of popular recreation and culture,* rather than exclusively a preparation for advanced scientific or engineering work, as is the too common custom in the schools proper. There is need that high grade teachers of science shall give thought to the extension of science study on a supplemental basis in order to insure a true scientific, rather than a "fake," leadership of such popular studies. There is also a great need and a very large demand for lectures and text books that convey accurate information and are true to scientific methods, but which are adapted to meet the demand of the untrained and non-professional student, yielding to him a greater intelligence and enlarged interest and appreciation, rather than requiring of him an engineering training. The preparation of such lectures and text books should, as largely as possible, be in the hands of those who

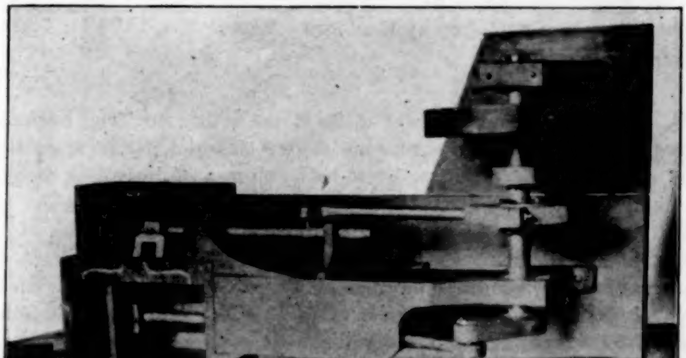
are recognized as high grade teachers and practical workers along scientific lines, and should not be left to those who for the sake of mercenary profit are willing to give information and produce literature of indifferent or questionable value under the guise of scientific instruction.

WOODEN MODEL OF A STEAM ENGINE.

By Fred A. Holtz,
State Normal School, Mankato, Minn.

The accompanying photographs show a wooden model of a steam engine. It is always of interest to the students and a great help to them in understanding the construction and operation of an engine.





This model is made wholly of wood except for nails and bolts. It is made of one and two inch pine. The cylinder is made square for simplicity of construction. The steam ports and exhaust are cut through the two inch partition between the steam chest and cylinder, and their course is indicated by white lines. The slide valve is dissected to show its construction and action. It is adjusted for cut-off. The eccentric can be properly adjusted on the shaft by means of set screws to give the desired cut-off.

The engine model is about four feet long. The sliding parts are rubbed with graphite to reduce friction, the rest is painted flat black.

Any one handy with tools can make a model like this. It is an interesting piece of work for students to make. The necessary information for construction may be obtained by examining a real engine.

Beginning with the fall of 1905, Bradley Polytechnic Institute, Peoria, Ill., will undertake to prepare teachers of manual training and domestic economy for elementary and high schools. Strong courses in these subjects have been prepared. All persons interested in these lines of work are requested to correspond with the director, Theodore C. Burgess.

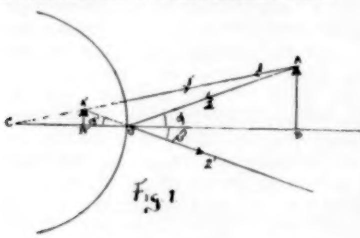
Country Life in America is without doubt one of the most attractive and interesting magazines published. When its pages are read and reviewed one is carried back, in his thoughts, to the country. The great number of pictures which it prints are all taken direct from nature. From the same press is issued another journal of equally high order, *The Garden Magazine*. This one is particularly adapted to the school garden movement. Both of these magazines should be taken by every school where nature study is taught. They are published by Doubleday, Page & Co., 133 East Sixteenth Street, New York.

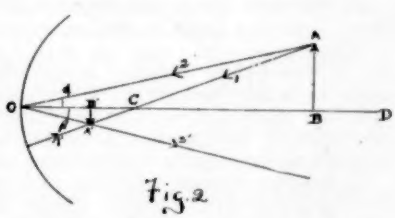
By mistake the statement was made in the article on "The Formula of Water," in the March issue, that phosphine to which the formula PH_3 is given decomposes into one and one-half volumes of hydrogen to one of phosphorus. It should have beeen *six* volumes of hydrogen. The molecule of phosphorus is P_4, as shown by the fact that 124 grammes of phosphorus occupy the same volume as 2 of hydrogen or 32 of oxygen or 17 of ammonia or 34 of phosphoretted hydrogen. It takes four volumes of phosphoretted hydrogen, therefore, to provide one volume of phosphorus vapor and one volume of phosphoretted hydrogen produces one and one-half volumes of hydrogen gas. The equation is $4\,PH_3 = P_4 + 6\,H_2$, which shows that for one volume of phosphorus vapor there are six volumes of hydrogen.

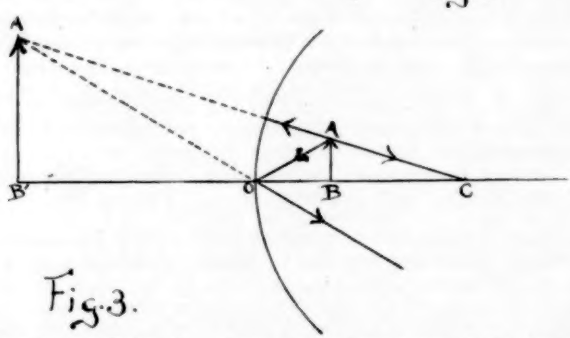
NOTE ON SPHERICAL MIRRORS.

By Edwin H. Hall,
Harvard University.

The very convenient rule that the length, perpendicular to the principal axis, of any image formed by a spherical mirror is to the length of the object as the distance of the image from the mirror is to the distance of the object from the mirror is usually proved by the use of a geometrical proposition with which the young student is not likely to be very familiar. The following simple construction, which must have been given before, but which is not given in most books dealing with the subject in question, may therefore be of interest to the readers of School Science and Mathematics:







In Fig. 1 let C be the centre of curvature, C D the principal axis, and A B the object. Find A′, the image of A, by extending backward to an intersection the two reflected rays 1′ and 2′, the characteristics of which are obvious. Neglecting, for the present discussion, the curvature of the image, we may take A′ B′ as the image of A B. But the plan of construction makes $\alpha=\beta=\alpha'$; and accordingly the triangles OA′ B′ and O A B are similar. Hence, A′ B′ : O B′ : : A B : O B.

Figs. 2 and 3 tell their own story.

PHYSICS REQUIREMENTS.

The following letter, published in *Science Notes,* the journal of the Pacific Coast Association of Chemistry and Physics Teachers, by Fernando Sanford, Professor of Physics in Leland Stanford University, while written especially to teachers on the Pacific coast whose pupils attend Stanford University, yet contains such excellent suggestions to teachers of high school physics, that it seems desirable to print it in full.

Mr. Edward Booth, Secretary Pacific Coast Association of Chemistry and Physics Teachers.

Dear Sir: In attempting to reply to your question of recent date as to the high school training in physics which our university department of physics would like to recommend, I wish to say, to begin with, that I do not think the subject matter of high school teaching should be greatly influenced by the wishes of the university faculties. I believe that, beyond all question, the best preparation for the study of physics in the university would be a thorough course in experimental mechanics under the supervision of a teacher with a thorough university training, but I am aware that it is futile to talk of such a course, or of any course in which enough time has been given any department of physics to lay a foundation for more advanced work in the university. After collecting statistics on the subject for several years, we have found that the freshman who has had no physics before entering the university does, on the average, just as good work and just as much work in our elementary courses as the man who has studied physics in the high school course. This may be due to our inability to arrange the work so as to take advantage of the high school training, but as matters now stand it is an incontrovertible fact.

I am not prepared to say just where the greatest weakness lies in the high school teaching of physics in this state, for I have not visited the high schools and inspected their work, but I have examined several hundred laboratory note books from this and other states and I have been much impressed with what has seemed to me to indicate a lack of careful supervision of the laboratory work of the pupils. It is not unusual to find the most flagrant mistakes overlooked by the teachers, and very often the experiments seem to have been assigned as a sort of "busy work" to keep the pupils occupied.

It goes without saying that I believe that elementary physics teaching should be mostly laboratory teaching, but so long as the laboratory is used merely to train the observation or give skill in manipulation, or as long as laboratory problems are assigned because they are easy or because they are difficult or because they can be performed by the apparatus which happens to be available, the training acquired by the pupil will be of little use to him in the study of physics. The only legitimate reason for assigning a laboratory problem in physics is because it is needed to teach something which the pupil should know at that particular stage of his progress; and unless it teaches this particular thing and teaches it so that it cannot be misunderstood, it has failed of its purpose.

I believe, too, that each laboratory experiment should be used for all it is worth. After the generalization has been reached inductively, it should be used deductively in predicting phenomena with which the student is not familiar, and that these predictions should in their turn be tested by experiment; i. e., the pupil should be trained in the method of discovering scientific laws. This feature of the work I should put above everything else as a training for university work, as well as a training for life.

I think, then, if I attempt to comply with your request and state explicitly what we wish to have done for the pupils to fit them for university work in physics, I cannot be more explicit than to say that we want them

trained in the rules of the game. We want them to know how to use their time effectively in the laboratory and in the study, and we would like to have a few of the fundamental principles of science taught so that they can be used in their everyday work. Whether this training is given in one department of physics or in another is a matter of little importance, but they cannot be given by any text book nor by a teacher who is not himself thoroughly trained in the methods of modern physics.

I am very glad to know of the formation of your association, and I believe it can be made of great value to the teachers and high schools of the state.

Yours very truly,

FERNANDO SANFORD.

The Chicago Center of the C. A. S. M. T. held a regular meeting in Hurd Hall, Northwestern University Professional School Building, Chicago, February 25th. Mr. Wood, educational director of the Y. M. C. A. work in Chicago, read a most interesting paper on "Supplemental Education as Applied to Science Teaching." He brought out the proofs that this form of education is absolutely demanded by people who are now actually employed in the trades; a class of people who are anxious to become more proficient in their line of work but who are prevented by the circumstances under which they live, from attending the public schools. There is, therefore, a demand for this new department of education. An abstract of this paper is printed on page 277.

The Jubilee of Hermann Georg Quincke, marking the fiftieth anniversary of his birth, occurred on Nov. 19 last. The number of *Drude's Annalen* for that month contains an excellent photogravure of this veteran worker in optics and molecular physics, with a good account of his life and contributions to science. No name is more inseparably connected with capilarity and surface tension. In the September number of the same journal will be found an interesting article by him on the conditions influencing double refraction in gelatine, connecting this subject with the change in the double refraction observed during the contraction of muscular tissue.

Looking over the volume of the *Zeitschrift Für den Physikalischen und Chemischen Unterricht* just completed I find it not less interesting and suggestive for secondary teachers than the preceding sixteen volumes. Among the leading articles those on apparatus for and course of instruction in the siphon; the parallelogram of motions; projection, and free fall may .be mentioned. The suggestions for new or improved or simplified apparatus are numerous, though many seem to be inspired by the reading of American or English journals. Foreign journals are more frequently actually quoted than is usual with German periodicals. I notice a number of references to SCHOOL SCIENCE AND MATHEMATICS. Under the history of science one may mention the development of the Doppler principle and of the present forms of the influence machine. Of 124 books reviewed, two are American books, three English, and a few French. Among others matters I notice a well reported attempt to introduce student's laboratory work, after the American method, into the Dorathea Realgymnasium of Berlin. Superior as is German instruction in physics, it has never been strong on this side.

E. A. STRONG.

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

DEPARTMENT OF METROLOGY, NOTES.

Metric Teaching in New England. The Eastern Association of Physics Teachers last year appointed a committee to inquire into the extent of the teaching of the metric system in the graded schools of the leading cities in New England. The report follows, accompanied by teachers' objections. Answers to those objections are also appended, as given by the Chairman, Mr. Fisher.

	Sent.	Re-tur'd	No.	Yes.
Me.	45	23	10	13
N.H.	17	10	3	7
Vt.	22	12	2	10
Mass	122	79	37	42
R. I	15	9	7	2
Conn	29	22	11	11
Tot'l	250	155	70	86

% of returns 62.

% of yes about 55.

Objections.

1st. Lack of time.

2d. No demand.

3rd. Of no value except in study of Science.

4th. Not a practical system.

5th. No object to teach it.

6th. Too slow a process.

7th. Easily forgotten.

8th. More easily learned at a more advanced age, *i. e.,* High School where it is used.

To judge from the per cent of returns, which is very large, it might justly be inferred that the subject is of considerable interest at the present time in educational circles.

Several papers stated that it was not now taught, but would most certainly be put into the course of study for the coming year, *i. e.,* this present school year.

To reply to the objections briefly in their order it may be said—

1. Introduce the Metric System instead of some of the worthless tables of denominate quantities now taught, as, for example, Troy Weight, English Money, Surveyor's Measure and others, for there are several.
2. If we are to wait for public demand, then we are weak and lack progressiveness.
3. Ignorance of the system.
4. Ignorance of the system.
5. Fine material for drill in work with decimals; for science work; to teach the coming generation that there *is* a *far superior system* for measuring; and, knowing it, to appreciate it, and *demand,* if necessary, its introduction into our graded schools.
6. Ignorance of the system.
7. A false statement, as I know from experience, having taught the system, not only to students of secondary schools, but also to children in graded schools.

8. An argument which may be applied to many subjects. Doubted, however, as applied to this subject, as it is *so readily* taught in our graded schools.

The above replies are few and brief. Many others may be advanced and large quantities of facts and experiences cited to prove the desirability of the universal introduction of this subject into our graded schools.

For the committee,

C. EDWARD FISHER, *Chairman.*

From Mr. Fisher's figures it appears that Vermont leads the list with 83% of those who report teaching the system, while Rhode Island stands at the foot with 22%, the order being—Vermont 83, New Hampshire 70, Maine 56, Massachusetts 53, Connecticut 50, Rhode Island 22. It is supposable that most of the schools from which no reply was received do not teach the system, otherwise they would have replied. If this is true, the actual percentage would stand much below that given, the total in that case falling to 34%, or about one in three.

The fact that the three most northern states give the highest percentage though farthest from the great centers, shows not greater educational progress, but rather persistence of custom. Probably the graded schools in almost all of the leading cities of each of these states have, at one time or another, included the metric system in their curricula. Take Boston, for example. Through the influence of Superintendent of Schools John D. Philbrick, and Melvil Dewey of the American Metric Bureau, the system began its course in the graded schools of that city in 1878, but, mainly by the dictum of Francis A. Walker, then President of the Massachusetts Institute of Technology, this teaching was discontinued in the lower grades in 1887, and relegated to the high schools, in which, ever since, it has been taught in only such classes—with rare exceptions—as take Physics and Chemistry. Walker's idea was to teach only the practical subjects, his telling argument being that not one graduate in three hundred ever had occasion to use the metric system. Thus one by one many cities have followed suit.

It would be interesting to know what percentage of cities in other states of the Union now teach the system in the grammar and primary grades. Why cannot the educational associations in the various sections of the country appoint committees to gather statistics on this point, with a view to agitating the more extensive teaching of this most important subject?

R. P. W.

ACCOUNT OF THE FRENCH MERIDIAN MEASUREMENT.

BY C. S. WADSWORTH,
Of Middletown, Conn.

Before the great revolution in France every little district and province had its own standards and system of weights and measures, some places even having more than one system in use. This gave rise to great inconvenience, ambiguity, misunderstandings, and law suits. Coupled with this was the difficulty in calculation inherent in the old systems, the same which we experience in our own, which is not uniformly arranged according to the decimal or any other system.

But this was only one of a thousand ills which rendered the old condition of France unbearable, and brought their own remedy in the great revolution. Nowhere has there ever been a revolution so thoroughly worthy of the name. The state of the nation, and of civilization, together with the genius of the French people, conspired to overturn existing conditions in everything. France was blessed with a large number of the foremost minds of the age, science saw the rare opportunity, and made use of it, and the metric system of weights and measures was brought into being, an immediate benefit to France, promptly seized upon by science in all nations and gradually adopted by civilized people throughout the world.

According to a proposition made by Talleyrand in 1790 to the *Assemblée Constituante* (National Assembly), the king was requested (May 8th) to write to His Britannic Majesty, requesting that a commission of British scientists be appointed to confer with the French upon the choice of a standard of measurement founded upon a natural basis. What reception this proposition met with can readily be imagined by anyone familiar with the attitude of the average Englishman to all things French and all things new, and with the history of the metric system among Anglo-Saxon laymen. Our British brethren have always refused to wear wooden shoes and eat frogs!

The *Assemblée Constituante,* upon the motion of Citizen Talleyrand, asked the Academy of Sciences to found the metric system on a natural base.

The Academy of Sciences confided the matter to a committee comprising Berthollet, Borda, La Grange, Delambre, Laplace, Méchain and Prony.

Various natural bases were discussed. The length of a pendulum beating seconds at Paris, the circumference of the earth at the equator, and the length of the quadrant of a meridian from the north pole to the equator. The last mentioned was selected as the best natural base, since the earth itself is one thing in which all men in all nations can see a natural unit. The exact truth of this proposition may be questioned since many of the most advanced among us seldom attempt a conception of the size of the earth, and still more rarely succeed in such an estimate. This learned committee erred in putting themselves, with their own broad conceptions of things, into the wooden shoes of the peasant proprietor, who, they figured, would be able to appreciate that his farm of a certain number ares was just such a fraction of the area of the surface of the globe. It would be impossible for any layman to make this complicated calculation.

But a system can best become international when it has no local earmarks, and no better base could be found than the one selected.

The idea of measuring a meridian was not a new one. In 1739-40 part of this same meridian of Paris had been measured by Cassini and Lacaille. The ten-millionth part of the arc thus calculated was adopted as the provisional meter. Similar measurements had been made of 3° of a meridian in Peru about 1730 by Bouguer and Lacondamine.

Delambre and Méchain undertook the survey of the Paris meridian from Dunkirk to Barcelona.

Delambre surveyed from Dunkirk to Rhodès and Méchain from Rhodès to Montjouy, near Barcelona.

Delambre set out armed with a proclamation of the king to the end that his operations might be expedited as much as possible, and that his signals, reflecting lamps (*réverbères*) and scaffolds might receive special protection from the administrative authorities. This proclamation gave the surveyors no end of trouble. It was issued to them the 24th of June, 1790, and was one of the last acts of the expiring royal authority. It could not, therefore, be available, and soon became a source not of protection and assistance, but of great inconvenience and at times of positive danger. Delambre was frequently arrested and his papers and letters examined. The surveyor had to appear before the municipal authorities, which at that time, on account of the great external danger from the nations allied against France, and of the still greater danger from internal dissensions, seem to have been in permanent session. When brought before these bodies the advisability of imprisoning them was discussed before their very faces, and they were continually obliged to show their passports. These passports, from an authority no longer existing, which was regarded by those then in power with the greatest distrust and hatred, only served to incriminate the scientists in the eyes of the authorities to whom the papers were addressed.

At Epinai it was found that their instruments were not clearly enough described in the passports, and the authorities, who perhaps saw in them some infernal machine calculated to destroy the Republic and bring back the power of the king, were of a good mind to take possession of them. The new tribunals, not being surrounded with any exclusiveness, were unable, even if willing, to protect the prisoners from the plebeian busybodies who were at that time showing such great activity all over France. Each curious person who turned up had to have the instruments explained afresh to him.

They were passed along towards Paris in their carriages. At St. Denys they had to drive through the midst of a great crowd of volunteers, just started on their way to defend the frontiers of France from the allied enemies of the Republic. The guards of the captured party proclaimed them in a manner not at all to the liking of the prisoners; in fact in such a way as to excite the democratic patriotism of the ignorant recruits against these learned wiseacres, these lettered emissaries of the king. A local officer who went by the pompous Republican title of *Procureur-Syndic*, with a view to shielding Delambre from the swords and bayonets of the enthusiastic Republicans, hustled him into a hiding place, where he remained for some time. The officer returned and said that there was no longer any danger, and the scientists were brought before the municipal authorities of the place. There explanations had to be begun afresh. Their letters to the different municipalities, through which it was expected they would carry on their operations, were opened and read until the exhausted reader had to ask for a rest. Delambre suggested that one should be taken from the remaining packages at random, assuring them that they were all alike, but that would not do. Few of the vast crowd

could hear, and, as night was approaching, fewer could see; and naturally none could understand. It was easy to convince the immediate bystanders that the instruments were almost as incomprehensible as the purposes of their owners, but a fresh assortment of walking interrogation points would surge up from the rear and again ask questions regarding the instruments, and, although reassured by an old man who remembered the former survey, still remained in doubt. Each new batch of hoodlums insisted upon a free course in geodesy. This desire for knowledge seemed to permeate the whole mob, and those compelled by their distance from the lecturer to remain in ignorance began to be in bad humor. The voices of some of these disappointed enthusiasts were heard uttering suggestions of lamp posts, nooses and similar expeditive measures, so popular at that time; means which solved all difficulties and ended all doubts.

The president of the district, by speaking in a politic way, secured an adjournment of the investigation, and the lives of the surveyors were spared. By this we get a glimpse of the difficulties experienced by scientists at this time, reproduced from the modest account of Delambre himself, published in 1810.

The troubles of the Delambre party at last resulted in advertising them so well in their proper light that their project became better understood and more widely known, after which affairs went more smoothly, although sometimes armed guards were required to protect their signals and stations from the attacks of ignorant fanatics.

With Méchain all went well for a time, but a severe accident spoiled one whole summer's campaign for him, keeping him in bed about three months, and for a year depriving him of the use of his right arm, but after a course of treatment at a watering place he resumed his work, suffering greatly from the cold, but nevertheless refusing to return to his home and interests at Paris until his work was completed. But in the sequel the unfortunate man was destined to give up his life in the cause. Though discovering an error in his calculation of the latitude of Barcelona, he resumed operations.

From their astronomical and geodesic measurements between these two points, they calculated the length of the terrestrial quadrant to be 5,130,740 *toises* of Paris. They were unfortunate enough to miscalculate this distance. Méchain made, or thought he made, an error of three seconds in the latitude of Barcelona, and subsequently, while attempting to correct his work and prolong these measurements to the island of Formentera (south of Iviza) in the Balearic Islands, he fell a victim to an epidemic and died in 1805. But the lack of precise exactness was no loss to the system, for it has since been discovered that the irregularity of the earth's surface is so great that any one meridian, such as the meridian of Paris, is not exactly the same length as any other meridian, and therefore the ten-millionth part of its quadrant, which was selected as the base of the metric system, would not have been, even if measured exactly, one ten-millionth of any other quadrant. While subsequent measurements have proved that the quadrant at Paris exceeds slightly the even length, it

appears that the quadrant at New York measures almost exactly 10,000,000 meters, or ten thousand kilometers.

This survey of the meridian was one of the greatest feats of science. The surveyors encountered and surmounted tremendous obstacles. Parts of the land were so hilly that they had to use, instead of landmarks and stations set by themselves or chosen at will, the belfries of churches. This was the case especially in the northern part, as far as Bourges. They found great difficulty in verifying the stations used in surveying the meridian in 1739, and also experienced great perplexity until they learned to discount the different light on round objects at different times of the day. The measure of each angle was repeated several times, with patience unbounded, and this extended along a chain of more than ninety great triangles, covering a distance of about 9.66 degrees, about equal to the distance from Chicago to Jackson, Miss., or Montgomery, Ala., the distance from Middletown, Connecticut, to the latitude of Charleston, S. C.

In surveying they used the reflecting circle or repeating circle (a valuable astronomical instrument for measuring lines with great accuracy) recently invented by Borda, a member of the commission. They found it a great help in verifying their work and reported that its centesimal division of the circumference was a help rather than a hindrance.

A full account of this wonderful survey was published at Paris by the survivor, Delambre, in four octavo volumes, appearing from 1806 to 1810.

The ten-millionth part of the distance from the north pole to the equator, being found a convenient length, was taken as the basis of the system under the name of "a meter." A bar of iridioplatinum, marked with this length, was deposited in the archives. To its multiples were given names with Greek, and to its sub-multiples names with Latin prefixes.

The cube of the decimeter, containing about a quart, was made the unit of volume, under the name of liter, and the weight of a cubic centimeter of water at just above freezing, or 4° centigrade, was made the unit of weight, a gram.

The progression of the multiples and sub-multiples is by tens. The commission had not been oblivious to the advantages of the duodecimal over the decimal system, but after carefully weighing the advantages of both under existing circumstances had decided emphatically for the decimal. Their decision should silence those who consider these savants as a set of impractical dreamers. Their reasons are set forth by Delambre (p. 301, Vol. III, of his work above cited) in his answer to a British critic who wrote for the Edinburgh Review.

This critic, although he deprecated their not going further in their reform and cutting loose from the decimal system, is on the whole favorable, hoping the system will soon be universally adopted, and reminding his countrymen that *"fas est ab hoste doceri."* The small advantages gained, says Delambre, from the use of the duodecimal system would be too dearly bought. Spoken as well as written arithmetic would have to be reformed. The greatly improved decimal money was as yet only used by government offices directly under the influence of authority, even the

most intelligent classes adhering to *sols* and *deniers* (12th of a *sou*). How difficult, how impossible, would be the change proposed when this improvement in the currency was so slow in gaining ground! The adoption of this additional reform, more specious than truly useful, would have been the most direct road to utter failure.

The system thus perfected was presented to the Assembly, which adopted it as the legal standard on the 18th of Germinal Year III (April 7, 1795). It was extended to the conquests of the republic and the empire, but as soon as these countries cast off the French yoke they also did away with the weights and measures of their hated conquerors. Indeed, the atmosphere of militarism engendered by the Napoleonic conquests seems to have been unfavorable to this commercial and scientific reform, as, indeed, it was also to many other advances in civilization. Herbert Spencer quotes Napoleon as an opponent of the metric system. It seems to be a vice of many great men in our own time to despise the day of small things. Napoleon issued, February 12, 1812, a decree abandoning the metric system, except for a few special cases.

July 4, 1837, Louis Philippe ordered the exclusive use of the metric system. This went into force January 1, 1840. Since then the French have not returned to their old measures, although in weaving and some industries, as well as in popular parlance, traces of the old systems are to be found. In this connection see Mr. F. A. Halsey in No. 971 of the publications of the American Society of Mechanical Engineers, page 405, where a number of these inconvenient anomalies is exultingly displayed.

In other countries for many years the system remained unknown. Holland was the first foreign country officially to adopt the French system. Nearly all continental nations and civilized states throughout the world have adopted it. The exceptions are Denmark, where the metric weights are used, but not other portions of the system, and Russia, where some progress is said to have been made toward introducing it. In England and the United States the use of the metric system is at present restricted. The system has many advocates in both these countries, and as the world tends to enlarge and different countries are brought nearer one another by commerce and improved facilities for communication, the cause seems favored by circumstances, and, in the opinion of many wise and practical men, is bound to prevail.

A metric bill has passed the House of Lords and one reading in the Commons. It seems likely that the measure will be passed if the Decimal Association can secure enough funds to carry the fight to a finish.

The mathematics teachers of Missouri are in keeping with the traditions of the state. A meeting has been called at Columbus for May 6, when it is proposed to organize an association of teachers of mathematics, with School Science and Mathematics as its official organ.

Report of Meetings.

NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION, BIOLOGY SECTION.*

W. M. SMALLWOOD.
Syracuse University, Chairman.

The biology section met in the botany room of the Syracuse High School. The first paper was read by E. D. Congdon of Syracuse University on "Field Work in High School Botany and Zoölogy." High School botany or zoölogy, he said, should include comparative study in the laboratory of the morphology and physiology of the most important subkingdoms of plants and animals, broadened by field work whenever possible. It should give a conception of the influence of environment on organisms, their plasticity and their activities. As a result, the student should acquire a general view of the science, a knowledge of local forms, scientific habits of thinking, and a sympathetic appreciation of living plants and animals.

One advantage of field work is that it can be easily graded as to difficulty. Another is that because of the variety of the problems presented, the student must take a broad view, and not go so much into details as in the classroom or laboratory. Field work also familiarizes pupils with the principles and forms that are studied in class.

In order to prevent the field work from degenerating into play, and to produce definite results, the teacher must be prepared before hand, and the class should be asked to answer definite questions on definite problems.

Seventy-five letters were sent by the writer to various city and village schools in the state inquiring concerning the amount of field work done. Thirty-five schools replied. Of these, two give eighteen trips per class; twenty-one give from four to twelve trips; eleven attempt three or four.

The most important object of field work is to study the adaptations, physiology, and ecology of plants, or the activities of animals. Suitable topics to consider are fruits and seeds; scars and associated buds; food relations of plants; in winter, the branching habits of trees; in early spring, budding and its relation to form; and the protection of some spring flowers from the soil and from cold; the struggle, of plant life for a foothold; the methods of seed dispersal; effects of shading; a study of pollination; various weeds; cryptogams; types of inflorescence; variations of stems; types and modifications of leaves. Herbarium collecting should be done sparingly.

Zoölogical field work is more difficult, owing to the variety of animal life. Some subjects of study are:—birds, insects, ecology, and the collection of forms for dissection.

Field work should not be crowded out by laboratory work. It is not necessary to dissect more than one vertebrate. The study of echinoderms

* The full report of this meeting will be published by the Board of Regents, Albany, N. Y.

is less important than a knowledge of the animals in one's own neighborhood. The greatest difficulty in zoölogy is the finding of suitable material near the school.

The careful observation of various insect orders and the collection of them serve for several excursions. These are afterward studied in the laboratory. Protective form and color, animal society, domestic life and industries may be taken up. Bird observation comes best in the spring.

In discussing the paper, Mr. Geo. Hargitt, of Syracuse High School, said that if one person in a class received, from the field work, an impetus toward original work, the labor expended on it is worth while.

Prof. Kirkwood, of Syracuse University, stated that he gave his pupils outlines for work in the field, and required them to write reports.

Mr. Bigelow, of New York, thought that as nature study gains ground in the common school, high school pupils will be able to do more advanced work.

W. H. Davis thought that a definite topic should be given, that the reason and source of statements should be stated, and that drawings should be made in the field.

C. H. Hahn referred to the impulse to collecting that might be given by field work.

W. Mann, of Potsdam, said that field work aroused the pupil's interest. The teacher must be prepared for his work, and interested in it himself.

C. S. Sheldon, of Oswego, spoke of the advantage of gardens either at home or at school.

Miss A. M. Crawford, of Buffalo, said that one difficulty was that of large classes. This may be partly overcome by student assistants.

Miss M. L. Overacker, of Syracuse, next read a paper on "The Making of a Laboratory Note-Book." She said, in part, that the first consideration is the book itself. The ideal note-book is not yet invented, or, if so, has not fallen into our hands. It should have a stiff cover, preferably black, with a neat label on the outside for the student's name. The inside of the cover should be provided with a printed slip having spaces for details as to study, student's name, and a blank form for a statement by the teacher at the completion of the course.

The paper should be in loose sheets, half ruled, with a red line at the left, half unruled, of a good quality of calendered paper. The mode of fastening is the unsolved problem. It should admit of easy replacing of sheets, yet be sufficiently firm and not of a kind to tear the paper.

All of our science classes use the same kind of note-book, hence the purchase of one cover may serve an economical pupil throughout his high school course.

Drawings should be in firm, clear outlines, with little or no shading, made with a sharp, hard pencil. Relative sizes of parts should be kept. All drawings should be carefully and fully labeled, in a neat print, and drawings should be symmetrically and serially grouped, each subject being kept distinct, and given a sufficient number of views to bring out the leading points of structure. No pupil is allowed to draw an object as it "ought to be" rather than as it *is;* nor to draw it to-day from his memory

of yesterday. We try to furnish material, that is as typical as possible, but allow no copying from the book.

Drawing from the compound miscroscope is a tough problem for the average beginner. We let them do their best, then show them a correct drawing, and let them try again.

The written notes, which should be in ink, allow a wide choice. It has not proven to be profitable to say simply, "Describe what you see." It is better to give a series of pointed questions which still do not answer themselves; in which case, if the teacher will refuse outright to answer questions, the pupil must, if he writes anything at all, do a little thinking. The method of Agassiz is probably ideal, but hardly practicable for thirty-seven minute periods in crowded classes.

We make our own laboratory directions as we go along, adapting them to the material in hand, and improving them as we can. Constant effort is made, by asking for comparative study of related structures, to lead the pupil to see the plant world as a whole and to read some meaning in it.

Each one's work should be done wholly without conference with his neighbors. When an exercise is completed, it is handed in, corrected—preferably with red ink—and returned for the pupil's correction. No work, without special permission, which is rarely given, is ever taken home.

Our reference books are brought into use by frequently sending the pupils to particular authors for light on especial points, the books being on the tables within easy reach. Occasionally, a selected list of references on a special topic is posted, and opportunity given for each pupil to record the references read.

Note-books are absolutely essential to laboratory work, and laboratory work in botany, either indoors or out, is the sort that really counts. Pupils often express decided opinions on this subject. They say, "There's nothing like it; it's the most interesting school work I ever did."

The note-book is the pivotal point in all science teaching, but, to be valuable, it must be honest, thoughtful and individual.

In reference to note-books, Prof. Smallwood said: "There is great need of reform. In general, not more than one in ten enter the biology course in Syracuse University without conditions on the note-book."

At the next session, Clarence H. Hahn, of New York, read a paper on "The Method and Scope of a Year's Course in Biology for the First Year of the High School."

Clarence H. Hahn's Paper.

Three factors are to be considered, the capacity of the child's mind, the material to be taught and the relation of the latter to the former. Each of these must be established by experience. A child of thirteen is capable of certain simple biological conceptions such as survival of the fittest, alternation of generations, etc., but not of complex relationships and principles.

The subject matter has value because it trains the mind and because it is of use in after life as a guide to the judgment and as economic information. The training value consists in developing the powers of observation, interpretation, formulation of relationships and general prin-

ciples, of inductive reasoning, the spirit of curiosity, the habit of weighing evidence, and skill in accomplishing difficult work.

Experience has shown that the subject matter of the science should be presented in such a way as to associate structure, function, relationships, ecology, etc., so that a clear and definite conception of a living organism results, a type of its class. Furthermore, the specimen in the student's hands is the most lasting instruction for the college student, and more especially for the younger students. Abstract textbook types, if numerous, do not give lasting impressions. Laboratory teaching with little supplemetary work is certain of results, while other methods are apt to be but temporary preparation for examinations. The use of instruments trains the mind indirectly.

In a course in botany, the phanerograms should be treated by types as is commonly done with simpler forms. The classification of leaves, flowers, stems, roots, etc., is only a means of recognizing plants and classifying them. Since that is no longer our object, it is better to take up types as exemplified in the following outline.

Botany Course.

Pleuococcus, spirogyra, basteria, slime mould, mould, mushroom, rockweed, moss, fern, equisetum, pine, trillium, corn, nasturtium, crowfoot, maple tree, ash tree, parsnip, Indian pipe. Take up each rather exhaustively, making use of charts and assigning outside reading. Make the class-work almost entirely laboratory study of the specimens. Treat the higher plants as outlined for the corn in the following: Roots, stem (nodes, cross section of green stalk, function of parts), leaves (venation, shape, microscopic structure, function); flowers, ear of green corn (silk, fruits), wind polliation; ripe corn (embryo, etc., germination through four or five stages). Call attention to monocotyledon characters, and compare with lower plants.

Zoology Course.

Amoeba, paramoecium, hydra or hyroid like parypha, sea anemone, coral, starfish, clam, earthworm, crayfish, grasshopper, fish (external, gills, dissected blood system prepared in alcohol, alimentary canal), frog (nervous system, development), lizard (integument chiefly), bird (feather, wing), rat or small animal dissected and preserved in alcohol (internal organs), skeleton of dog, beef heart, beef eye, histology of muscle, nerve, bone, gland, connective tissue, epithelium.

A more or less exhaustive study is intended for each of the above forms, use being made of good charts when good material is not at hand. Laws and relationships are to be brought out by questions and assigned text-book reading.

In the discussion which followed, T. A. Chesebrough, of Yonkers, questioned whether teachers now giving advanced biological courses in third and fourth years would be willing to be so limited in time and scope as this paper suggested. He had in mind a partially planned course in biology, with human physiology as the center.

Prof. Smallwood said that Regent's schools must have some general uniformity as to courses.

M. A. Bigelow, of Columbia, said that any biology that could count for college entrance must be taken late in the course. He believes, however, in an earlier simple course, but its place is alongside of manual training.

Inspector Clement, of the Regent's office, asked if Superintendent Maxwell's science course was followed in New York. Prof. Bigelow said that it was, but teachers are allowed to use their judgment to some extent.

Mr. Hargitt approved of biology in the first year, but thought that often too much is attempted.

Mr. Gary thought the course too full. He would make zoölogy two-thirds invertebrate. Mr. Hahn replied that he preferred that two-thirds should be vertebrate.

Mr. Gary suggested that charts could be used to show invertebrates, thus doing away with the objections to dissection.

Miss Palmer, of Utica, doubted whether so much time should be given to the subject of energy.

The next subject was a "New Species of Primrose." Specimens were shown which Prof. J. E. Kirkwood, of Syracuse University, had obtained from Prof. De Vries, of Amsterdam, Holland, illustrating the formation of a new species by mutation; a complete new form having appeared suddenly, instead of by accumulating minute variations.

Prof. M. A. Bigelow, of Columbia, now read a paper on the "Scope and Method of Scientific Nature Study."

The subject was discussed under four headings: (1) What is nature-study and how related to natural science of higher schools; (2) the scope of nature-study; (3) the values and aims of nature-study; (4) is nature-study scientific?

(1) The line between nature-study and natural science should be, in the opinion of the speaker, on basis of generalizations and principles which are fundamental in organized science. Nature-study is primarily the simple observational study of common natural objects and processes for the sake of personal acquaintance with the things which appeal to human interest directly and independently of relations to organized science. Natural-science study is the close analytical and synthetical study of natural objects and processes primarily for the sake of knowledge of the general principles which constitute the foundations of modern sciences.

(2) Under the heading, "Scope of Nature-Study," the proposition was discussed that all elementary-school studies of nature should be nature-studies, as defined above. At present some of our high school work, chiefly biological, is nature-study, but this is rapidly becoming a duplication of work of the lower school.

3. The educational values of nature-study are similar to those of natural science, and may be grouped under (a) discipline and (b) information along practical, intellectual, moral and æsthetic lines. From these values we lead to the aims: (a) To give general acquaintance with and interest in common objects and processes in nature; (b) to give the first training in accurate observing, and in other simple processes of the scientific method; (c) to give pupils useful knowledge concerning natural objects and processes as they directly affect human life and interests.

(4) Nature-study presented according to principles advocated in the foregoing is in harmony with the methods and rules of science, and deserves to be called scientific. But it should stop short of the principles and generalizations characteristic of elementary science. (The full text of this paper will be published in connection with a series of papers by various writers in The Nature-Study Review.)

On this paper L. B. Gary, of Buffalo, presented the following discussion:

The possible scope of nature-study is broad, the practice is limited. The specialist may be prejudiced in favor of his own subject. The tendency has been toward the study of life, and those simple, chemical and physical phenomena most intimately associated with it. Lessons from life have a human interest, arouse sympathy and tend to develop kindness of heart.

Plant study can well begin with leaves of trees and be continued by the study of flowers, seeds and simple ecology, while self-interest can be aroused by the cultivation and ownership of flower, fruit and vegetable gardens. The animals best adapted to the aims of nature study are the domestic animals, insects and birds. Disagreeable forms may be included, if so studied as to overcome timidity and thus make life pleasanter.

The main method is the inductive, but the deductive may well be used occasionally; the originality of the teacher determining the precise methods best suited to obtain results. The nervous city child needs physical contact with nature; hence the value of excursions. The country child needs intellectual contact in order to see in the commonplace facts of his experience a deeper meaning, a new relationship and a hidden beauty. He needs nature literature and drill in English composition. Harmony with the pupil's environment should be developed by the study of local material and through collections made by the pupil; his observing power should be developed by inductive questions and by emphasizing the importance of discovery for himself; his reasoning power should be developed by the comparison of observed facts and by drawing conclusions therefrom; expression is developed by drawings, oral and written exercises; sympathy and kindness of heart comes through considerate treatment of living things.

At the business meeting of the section, C. H. Hahn, of New York, was elected Chairman, and Mary L. Overacker, of Syracuse, Secretary.

MEETING OF THE NEW YORK CHEMISTRY TEACHERS' CLUB.

The tenth regular meeting of the Chemistry Teachers' Club of New York was held after dinner at the Savoy, in the Board of Education Building, February 11, 1905.

Messrs. Hale, Sohon, Stocker, Mills and Whitsit reported on the evolution of hydrogen, using sheet zinc (commercial) and 5% (by volume) C. P. sulphuric acid. The time required for the solution of one gram of zinc varied from three to six hours, sometimes longer. By the addition of 5% concentrated copper sulphate solution to the acid, the results were generally uniform, at about 20 minutes. Dr. Hale found that the rate was at a maximum when 5% sulphate was added. Mr. Mills stated that after the first 50 cc. of hydrogen was given off the rate was practically uniform in all cases, but when sulphate was used the rate was uniform throughout.

Messrs. Brownlee, Currie, and Easton reported on the corrosion of steel (knitting needles) exposed to the vapors of chemicals. The needles being passed through the corks of test tubes, but not touching the contents. Over concentrated sulphuric acid no change was seen, (the exposures lasted six weeks); over dilute acid, a very slight pitting. Concentrated nitric acid, at first a gray color, then a crystalline deposit. Concentrated hydrochloric acid, immediately a gray film increasing in thickness and showing striations lengthwise of the needle, finally becoming red and moist.

Dilute acid first showed a blue scale, changing to orange. The needle point, however, remained gray.

Distilled water showed very little rust. Carbondioxide water, however, showed more. NaOH and KOH (10% solutions) showed little effect.

Mr. Easton showed some needles which had touched the concentrated acid, the needle end separated into fibres like a brush.

To determine the oxygen in air, Dr. Allen filled a test tube about one-third full of pyro, marked the level with a rubber band, filled to mark with KOH solution, closing with thumb, shaking and inverting into water. When cool, close reverse and from burette measure residual air space; also by burette determine volume of air taken.

Mr. Allen also showed an apparatus in which the measured air in an eudiometer was passed into a cylinder containing copper gauze, wet with alkaline ammonium chloride. After absorption the air was forced back by leveling bottles into the eudiometer and remeasured.

Dr. Woodhull used a 25 c.c. eudiometer, in a cylinder about the same length, filled with water. The air in the eudiometer is measured at adjusted levels and the eudiometer lowered over a wire holding a phosphorus pellet. After absorption, the audiometer is raised, to remove the P and adjust levels, and re-read.

Dr. Fay showed a piece of apparatus combining in one straight tube the eudiometer and absorption chamber. The lower (closed end) half of a tube contained phosphorus rods, ⅛ inch in diameter, held in place by a perforated stopper.

The upper half was graduated from the end. The tube having been filled with water, is partly emptied and the air space observed. It is then closed and inverted, over water, whereby the air passed into the phosphorus chamber; after cooling it is closed and again inverted, and the residual air measured. After filling with water, it is again ready for use. Dr. Fay used a vessel constructed like an "unspillable" ink well. The tube was closed by being pressed against the bottom of the vessel, and inverted, when the vessel furnished water to replace the absorbed oxygen. Dr. von Nardroff and Mr. Huntington used the same kind of tube, but inverted into a vessel of water, Dr. von Nardroff opening and closing the tube by a brass plate held by a spring; Mr. Huntington by a cork stopper with a lateral perforation, to allow its opening or closing without affecting the pressure. M. D. Sohon.

THE COLLEGE ENTRANCE EXAMINATION BOARD'S SYLLABUS IN CHEMISTRY.

M. D. Sohon.*

Morris High School, New York.

The syllabus in chemistry for the New York High Schools was recommended to the City Superintendent by a committee of seven teachers appointed from the various schools in June, 1901.

As one of the requirements for graduation then announced, the pupil

* Mr. Sohon was chairman of the committee referred to in the paper.—Ed

should pass the tests of the College Entrance Examination Board. In view of this fact the committee recommended the adoption of the Board's syllabus.

The syllabus represented a new course of work, differing in content and method from usual courses and outlined a systematic development of the subject radically different from standard tests. It has received criticism on various points, much that has been said I think unfair, if we look to the intent of the syllabus. In the following I have attempted to point out what I consider the purpose of the course of work, and I refrain from criticising it.

The opening paragraphs are clearly a list of suggested topics. The critcised list of experiments is not merely a list of exercises that are to be considered acceptable, but each experiment is carefully stated not alone as to its material, but the sequence points to a definite form of instruction, of high standard with carefully selected material—inductive instruction, with individual quantitative work.

In the following outline I have mentioned each experiment *in its order in the syllabus* (experiment numbers are given):

> In the introductory section, (1) the composition of the air is determined; (2) by the action of heat on a certain body, a metal is obtained and a *material* acting similar to *something in the air.* (3) Starting with a metal the same (physical) process brings about a reverse action. (4) Such (metallic) oxides have certain general resemblances and differences. Similarly non-metallic substances are used (5-6).

This section furnishes clear cut illustrations of chemical action, solubility, distinctions as to acid, base, salt and neutralization.

> Physical conditions, temperature and pressure, as the factors in the states of matter. (8, 9, 10.)

The chemistry of common things is begun in a thorough study of the *chemistry* of water.

> (11) Oxygen (reviewing No. 1, No. 6) is prepared and (12) studied, as to its chemical and physical properties. This introduces (13) water, which is decomposed by sodium; (14) hydrogen is also prepared in the usual way that its characteristics may be noted (15).
>
> The relations by weight and by volume, in which H and O combine, are to be determined, (16, 17), and having produced a quantity of the material, it is shown, in its physical properties, to be identical with water (18).
>
> Water is then electrolysed (19) and the products shown to be qualitatively and quantitatively identical with the materials used in the former synthesis.
>
> The vapor density of water (20) is determined and the formula derived.

These experiments lead in a masterly manner to the qualitative and quantitative proof of the composition of water by analysis and synthesis, and to its symbol. The work is necessarily long and intricate, so difficult

that few texts attempt to develop the general notion expressed in a chemical formula, but it is here brought out in a series of concise exercises.

Preliminary to the further study of compounds, are a number of exercises for the detection of metals—not a systematic course in qualitative analysis, but such tests as would indicate whether or not, *e. g.*, blue vitriol is a copper compound.

> Any of the metals named could be detected by at least one of the four simple tests: the flame tests (21); borax beads (22); cobalt nitrate coloration (23); reduction by zinc (24, 25).
>
> Chlorine is prepared (26) and studied (27) as was oxygen; combined with hydrogen (28) the acid examined and analysed (29, 30) affording an excellent illustration to introduce Avogadro's Law. Other compounds of chlorine are prepared and studied by the methods 21, 25.
>
> Similarly the other halogens are prepared and studied in their typical compounds, and relative "chemism" (32, 37).
>
> The relative activities and weights being noted, the next topic is the determination of combining and atomic weights (38, 39, 40).
>
> The same course of treatment is indicated for the study of sulphur, its acids and salts (41, 46) and for nitrogen oxides and acids.
>
> Valence and oxidation and reduction are introduced with the change from chromate to di-chromate and vice versa (52), chromium as acid and base forming element (53), and the iron salts (54, 55).
>
> The same general treatment is extended to carbon. Carbon is identified (56) in its compounds, some of these being prepared (57, 58); carbon dioxide is studied in some of its important relations (59, 61).
>
> Alcohol, ether and soap are also suggested (62, 64).

In the foregoing, *each* experiment in the "list" has been included, and its object shown (as it appears to me.) I do not believe that I have introduced any topic not called for by the syllabus. But it should be noted that I have mentioned but a small proportion of the topics included in the "outline," the metals have been only incidentally touched, and the usual technical treatment ignored.

REPORT OF THE MATHEMATICS SECTION NEW YORK STATE TEACHERS' ASSOCIATION.

W. H. Metzler,
Syracuse University, Chairman.

Prof. Metzler presented a paper on "Geometry," the main object of which was to consider the following questions:—What is geometry? Why should it be studied? How should it be taught? A somewhat detailed account, also was given of the results that should be derived from the study, and finally, some general conclusions were reached as to methods of teaching.

F. L. Lamson, University of Rochester, made some "Suggestions on the Teaching of Elementary Mathematics."

Each teacher, he said, should have with each class some one definite purpose constantly in mind. To be able to fix upon a purpose that will have practical results, the teacher must make a close study of the history of mathematics, the vocabulary of the science, must constantly review the high school algebra in the light of the science, must constantly review the and read carefully and critically the best literature on the subject of the teaching of elementary mathematics.

Mr. W. Betz of the East High School, Rochester, N. Y., gave a very complete outline of the laboratory method of teaching mathematics. He also read a carefully prepared paper giving the details of the plan for putting the laboratory method into operation, a plan that has proved practicable with him in his teaching in the East High School in Rochester. These papers will be incorporated in the regent's report.

The meeting was well attended and nearly all present took an active part in the discussion. O. C. KENYON.

THE MATHEMATICAL CLUB OF THE UNIVERSITY OF ILLINOIS.

At the regular meeting of the Mathematical Club on February 11, 1905, the following officers for the second semester were elected.

President—Miss Nelle Reese.

Vice-President—Mr. H. M. Reddick.

Secretary and Treasurer—Miss Candace I. Robinson.

The following papers have been given before the Mathematical Club during the past semester:

1. Miss Jessie Bullock, "On Methods in Teaching High School Mathematics."
2. Miss Estella McCarthy, "The Development of Mathematics in the Colonial Schools."
3. Miss Grace Allen, "Mathematics in the Grades."
4. Miss Nelle Reese, "Mathematics in Illinois Colleges."
5. Miss Pearl Belting, "The Development of American Mathematics Following the Revolution."
6. Mr. E. R. Smith, "Mathematics in American Universities."
7. Mr. A. H. Wilson, "Mathematics in German Universities."
8. Mr. H. M. Reddick, "Mathematics in British Universities."
9. Miss Mabel Kilpatrick, "Foreign Influence on American Mathematics."
10. Mr. E. B. Lytle, "Mathematics in France."

At the meeting on October 1, Prof. H. L. Rietz gave a report of the mathematics section of the International Congress of Arts and Sciences at St. Louis, which Section he attended. On January 21 Mr. E. W. Ponzer gave to the Club a report of the December meeting of the Chicago Section of the American Mathematical Society.

PERSONAL NOTES.

Mr. W. C. Brenke, '96, has been appointed Austin Teaching Fellow in Astronomy in Harvard University.

Miss Mary Anderson, '03, is professor of mathematics in the Illinois Woman's College at Jacksonville, Ill.

Miss H. Amanda Westhold, '03, is teaching mathematics in the Quincy (Illinois) High School.

Mr. Noah Knapp, '04, is teaching mathematics in the Rock Island (Illinois) High School.

Miss Mildred Sonntag, '04, is principal of the Lexington (Illinois) High School.

Miss Maud Patterson, '04, is teaching mathematics and German in the Urbana (Illinois) High School.

Mr. A. R. Crathorne, '98, who has been for several years instructor in mathematics in the University of Wisconsin, is now studying under Hilbert and Klein at Göttingen.

Mr. G. H. Scott, '96, is professor of mathematics and astronomy in Yankton College, Yankton, S. D.

ERNEST B. LYTLE.

NOTE TO INSTRUCTORS IN MATHEMATICS.

BY J. E. GOULD,
Seattle, Wash.

The following books have been found most useful to instructors and students of high school mathematics. The list is submitted to the instructors in the high schools with a view to assisting them to some extent in the selection of books for the library or for the teacher's private use. An interchange of opinions regarding these and other books will be helpful to all teachers, and suggestions concerning other books of reference will be gladly received by this department.

Number and Its Algebra: Arthur Lefevre; D. C. Heath & Co.; $1.25. A syllabus of lectures on the theory of number and its algebra. The book is very valuable to the teacher and can be read by students advanced in the high school.

Teaching of Elementary Mathematics: D. E. Smith; McMillan Co.; $1.00. This book treats of the development of arithmetic, algebra and geometry. It presents the results of the best of mathematical scholarships to be applied in class-room teaching. A good list of books for the teacher is also given.

Algebra (two volumes): Chrystal; Macmillan Co.; $7.50. This is probably the most reliable and complete work on the subject within the grasp of the high school student. It is recognized as a standard book of reference.

The Number System of Algebra: H. B. Fine; D. C. Heath & Co..; $1.00. In this text the number system is treated theoretically and historically. The exposition of the number concept, the negative, the irrational and the imaginary is valuable.

The Study and Difficulties of Mathematics: De Morgan; The Open Court Co.; $1.25. A series of excellent lectures on many important points in the subject.

Elementary Practical Mathematics: Frank Castle; MacMillan Co.; 60 cents. As a source of practical problems and illustration of graphic methods in algebra and arithmetic, this book is very useful.

Elements of Applied Mathematics: C. M. Jessop; Deighton Bell & Co.; $1.25. Easy applications of mathematics are here presented which give students continual inspiration in the work of real life.

History of Mathematics: W. W. R. Ball; MacMillan Co.; $3.25. This is a reliable, brief history of the subject, and an interesting reference book for both teacher and student.

Computation: E. M. Longley; Longmans, Green & Co.; $1.00. This is an account of the chief methods for contracting and abbreviating arithmetical calculations.

Psychology of Numbers: McLellan & Dewey; D. Appleton & Co.; $1.50. No teacher of mathematics can afford to be without this book. It carries the ratio idea of number to an extreme, but it is the clearest and best exposition of the psychology of the subject written by American authors.

Heath's Mathematical Monographs: D. C. Heath & Co.; per copy, 10 cents. These are freshly written pamphlets upon the history, theory, subject matter and methods of teaching both elementary and advanced topics.

Trigonometry: Crockett; American Book Co.; $1.25. An excellent textbook in advance of high school work.

The Common Sense of the Exact Sciences: W. K. Clifford; D. Appleton & Co.; $1.50. An interesting discussion of the subject, and one which, for the most part, can be easily understood by secondary students.

A valuable report for the secondary teacher is that of the Committee on the Correlation of Mathematics and Physics in Secondary Schools. This is a part of the proceedings of the Central Association of Science and Mathematics Teachers. Copies can be obtained from Mr. E. Marsh Williams, Treasurer High School, LaGrange, Illinois; price 25 cents.

The second meeting of the New York section of the Association of Teachers of Mathematics of the Middle States and Maryland was held at the College of the City of New York on Saturday, March fourth. After an address of welcome by President Finley, Prof. Joseph Bowden of Adelphi College, Brooklyn, and Mr. John H. Denbigh of the Morris High School, Manhattan, read papers on "The Graph in Early Algebra." The next subject, "The First Year in Algebra," was introduced by Miss Margaret L. Ingalls of the Girls' High School, Brooklyn, who was followed by Mr. Oscar W. Anthony of the DeWitt Clinton High School, Manhattan. The discussion which followed the formal papers was animated and interesting.

Biology Notes.

"Physicological Draught in Relation to Gardening," and "Biology and Physical Sciences as Taught in Russian Secondary Schools," are titles of brief articles in the January number of "Plant World." They will be of interest to teachers of biological and physical sciences.

There has recently appeared as a reprint from the October, 1904, Bulletin, Torrey Botanical Club, an interesting article by W. E. Kellicott on "The Daily Periodicity of Cell Division and Elongation in the Root of *Allium*." It is found that there is a definite relation existing between the period of greatest cell-division and the period of most rapid elongation. The primary maximum of cell-division and primary minimum of elongation occur at about 11 P. M. The primary maximum of elongation coincides with the secondary minimum of cell-division and occurs at about 5 P. M. The primary minimum of division coincides with the secondary maximum of elongation at about 5 A. M. Considerable irregularity occurs from 3 A. M. to 7 A. M.

"The Proceedings of the Ohio State Academy of Science for 1904" contains an article of interest to teachers of botany, entitled "Ecological Study of Brush Lake." This lake, which is of glacial morainic origin, lies in west central Ohio, and may be taken as a type of those small lakes that are not uncommon throughout the central states. The authors, Messrs. Schaffner, Jennings and Tyler, determined seven plant zones, and by means of photographs, descriptions and identification of the plants found give an instructive presentation of the peculiarities and relationiships of the various zones. The paper will be suggestive to teachers whose pupils are observing such lakes or the swampy regions that follow them.

"Conditions of Treated Timbers Laid in Texas, February, 1902," is the title of Bulletin No. 51 of the U. S. Bureau of Forestry. Dr. Von Schrenk, the author of the bulletin has given much time to a study of the fungi that destroy railway timbers, and while it is yet too early to obtain final evidence concerning the economic importance of his experiment, valuable results have been derived. Two and one-half miles of the Gulf, Colorado & Santa Fe railway, near Somervile, Texas, are being used for the experiments. Of the thirteen kinds of timbers used as ties, specimens of each were treated by various processes, and some ties of each kind were left untreated. After two years had elapsed practically all the untreated timbers showed more or less decay from fungi. All ties treated by the zinc chloride and the Wellhouse treatments, and all properly treated by the Allardyce process (the latter two are patent processes) show no signs of decay. Other treatments show results that are somewhat less satisfactory.

The Century Magazine for March contains an excellent account of the work of Mr. Burbank in producing new and improved varieties of edible and beautiful plants. It is said that the work of this man, more than all

else, was the occasion of the recent visit of Professor Hugo De Vries to this country. Interest in the economic aspects of Mr. Burbank's experiments is surpassed only by the deeper significance of the variations of his plants and the perpetuation of those variations to form new varieties and species. The list includes an edible cactus free from spines, needles and fibres, and that will flourish in arid regions; a thornless blackberry, and a white blackberry; fruit trees whose buds will withstand heavy frost; "plumcot," a new friut made from the American wild plum, a Japanese plum and our apricot; numerous and astonishing changes in floral structures. Biologists who from Professor De Vries' visit received new stimulus in their interest in the laws that underlie the production of new species will welcome the promised continuation of this popular description of Mr. Burbank's work.

Zoölogy teachers will be interested in the last number of "Bird Lore" (January-February, 1905), as it contains the report of the National Association of Audubon Societies. A history of the Audubon movement is given by way of introduction. The states having Audubon Societies are indicated on a map by the date when each was organized. Thirty-five states, one territory, and the District of Columbia now have societies. Efforts for uniform bird legislation are bringing results, for the A. O. U. model law is now in force in twenty-eight states and one territory. These are also shown upon a map. The Thayer fund is growing. The amount last year was sufficient to pay thirty-four wardens in the United States for the purpose of protecting sea-birds during the breeding season. Following the thirteen pages of history the report of the national committee for 1904 is given. In this, lines of work are suggested for state societies, and then follows interesting discussions of bird protection abroad, in Canada, Mexico, and the Pacific islands, and finally a short consideration of traffic in live birds. About forty-three pages are occupied with reports of each of the state societies, this being followed by a statement of the Thayer fund.

The report gives an encouraging outlook for the much needed bird protection. There is no doubt that a great deal is being accomplished by this body of earnest workers known as the Audubon Society. Matters concerning bird protection deserve a prominent place in our zoölogy courses. This is made especially evident by some facts mentioned on page 40 of this same number of the magazine. Secretary of Agriculture Hon. James Wilson is quoted as saying: "All the gold mines of the entire world have not produced, since Columbus discovered America, a greater value of gold than the farmers of this country have produced in wealth in two years; the products of the farms for this year alone (1904) amount to more than six times the capital stock of all the national banks." The statement is also made that insects destroy annually agricultural products to the value of $300,000,000. Now, when we consider in connection with these statements the facts that birds are the chief enemies of insects and that beneficial birds have been decreasing in numbers during the last few years in most parts of the United States, it is surely time that people become informed of their value.

Book Reviews.

Introduction to Geometry, by William Schoch. Pp., IV-137. Boston: Allyn & Bacon. 1904.

Another attempt is before us in this book to make the grade work in geometry a really educational factor. The author shows by the procedure of this little book that he is familiar with the way boys and girls of the grades must approach mathematical ideas. Each subject that is taken up is given a very vital connection with such real problems and conditions as pupils of the seventh and eigth grades are able to appreciate the value of. The work is constructive, but thoughtful and connected with reality. The wheel, the bow and arrow, the railroad track, the movement of the hands of the clock in the measurement of time, the mapping of street lines of cities, the drawing and designing of ornamental and useful figures, the measurement of distance and of dimensions of objects with the eye, thumb and lead pencil, the graphing of useful statistical data, the measurement of heights, have all been made to do efficient service in leading pupils to the generalizations which they themselves can make and which constitute the conceptual basis of such geometry as is adapted to the needs of pupils for which it is intended, and of such alone as may form a real foundation for high school work. This litle book of less than 140 pages is something better than a compressed and desiccated high school treatment of geometry. Those teachers who believe that geometry should be somewhat isolated from arithmetic and algebra though still treated by arithmetical methods essentially, will find this book in conformity with their views.

In the writer's opinion, it is educationally wasteful and unfortunate to bind up the geometry that is to be put into the grades into a separate book and to assign it to a particular half year or year, of the seventh, or eighth grades. The same mistake is usually made with grade algebra. This is the main criticism to be made against the appearance of this book. All interests concerned demand that the grade work in geometry, of whatever sort, as also in algebra, shall be closely correlated all along the way with the arithmetic. The real reason for the introduction of these subjects in the elementary school is *for the benefit that they confer upon the arithmetic.* This benefit is more than half lost unless the ideas of these subjects come in at the proper time and place, in their natural settings with reference to the topics of arithmetic. This makes these subjects concrete in the best sense, viz., in that they are always being studied in the midst of their meanings.

Doubtless the author has in mind that in the present state of pedagogical attainment, teachers need to look at the geometry in a narrower and more unified way than would be easily possible if the matter were distributed as it should be with regard to its arithmetical bearings. But it is the habit of the writers and publishers of books, rather to teach teachers than pupils. This habit can be understood commercially, though hardly condoned educationally. To those who believe in compartmentalizing the subject-matter of grade mathematics this little book will be an interesting contribution to practical pedagogy.

G. W. Meyers.

A Chemistry Manual and Loose-Leaf Note Book, by John Whitmore, Instructor in Chemistry, Stamford (Conn.) High School. Atkinson, Mentzer & Grover.

This manual consists of seventy-one experiments, well chosen for the most part, although comparatively few schools could supply pupils with the apparatus suggested for electrolysis in experiment XI., even if it is wise to place such expensive and fragile apparatus in the hands of beginners. The book contains few typographical errors, though the proofreader overlooked the repetition of the last few lines of experiment X. and the pneumatic "tub" of other experiments gives place in experiment XXXI. to the more familiar term pneumatic trough.

The arrangement in experiment XV. for determining the proportion of nitrogen in the air, is a decided improvement over the more common way of thrusting the receiver of air down over the burning phosphorus.

In example XXIX. the reaction should be $Na\ NO_3 + H_2SO_4$, not $2\ Na\ NO_3$, for at the higher temperature required for the sulphuric acid to liberate a second molecule of HNO_3, the latter undergoes decomposition.

The work begins with experiments on methods of weighing, use of chemical balance, measuring volumes, physical and chemical charges, glass-bending, oxygen, hydrogen, electrolysis of water, carbon, nitrogen, halogens, sulphur and their compounds; then sodium, potassium and ammonia, with the corresponding hydroxides. The quantitative experiments are preparation of carbon dioxide, sodium chloride, calcium sulphate, determination of crystal water in the blue vitriol and gypsum and the quantitative preparation of hydrogen by action of sodium on water. Following these the metals are studied in groups with reference to their separations and identification; and a similar study is made of the more common acid radicals. Experiments LXV. to LXXI. treat of organic compounds such as methane, chloroform, acetic acid, ethane, ether and alcohol.

There is a table of contents, table of elements and atomic weights (masses), and a table of metric equivalents. A. L. Smith.

SCIENCE AND MATHEMATICAL SOCIETIES.

Under this heading is published each month the name and officers of such societies as furnish this information.

Central Association of Science and Mathematics Teachers.

President, Otis W. Caldwell, State Normal School, Charleston, Ill.
Secretary, Chas. M. Turton, 440 Kenwood Terrace, Chicago, Ill.
Treasurer, E. Marsh Williams, High School, La Grange, Ill.

Annual meeting Friday and Saturday immediately following Thanksgiving.

Chicago Center, C. A. S. and M. T.

President, W. C. Hawthorne, Central Y. M. C. A., Chicago.
Vice-President, P. B. Woodworth, Lewis Institute, Chicago.
Secretary, C. E. Osborne, High School, Oak Park, Ill.

North-Eastern Ohio Center, C. A. S. and M. T.

President, Franklin T. Jones, University School, Cleveland.
Vice-President, Miss Winona A. Hughes, High School, Mansfield, Ohio.
Secretary-Treasurer, Clarence W. Sutton, Central High School, Cleveland.

Eastern Association of Physics Teachers.

President, George A. Cowen, W. Roxbury High School, Jamaica Plain, Mass.
Vice-President, Irving O. Palmer, Newton High School, Newtonville, Mass.
Secretary, Fred R. Miller, English High School, Boston, Mass.
Treasurer, Arthur H. Berry, Classical High School, Providence, R. I.

Natural Science Association. A section of the Ontario Educational Association.

Hon. President, T. L. Walker, Toronto, Ont.
President, T. H. Lennox, Stratford, Ont.
Vice-President, S. B. McCready, London, Ont.
Secretary-Treasurer, E. L. Hill, Guelph, Ont.

Annual meeting, Toronto, Tuesday, Wednesday and Thursday of Easter week.

Indiana Science Teachers' Association.

President, N. H. Williams, Terre Haute.
Vice-President, M. T. Cook, Greencastle.
Secretary, W. H. T. Howe, Indianapolis.
Treasurer, J. F. Thompson, Richmond.

American Physical Society.

President, Carl Barus, Brown University, Providence, R. I.
Secretary, Ernest Merritt, Cornell University, Ithaca, N. Y.

Association of Ohio Teachers of Mathematics and Science.

President, Charles S. Howe, Case School of Applied Science, Cleveland.
Vice-President, Alan Saunders, Hughes High School, Cincinnati.
Secretary, Thomas E. McKinney, Marietta College, Marietta.

Science Section.

Chairman, Will G. Horwell, Ohio Wesleyan University, Delaware.
Secretary, Jacob W. Simon, Woodward High School, Cincinnati.

Pacific Coast Association of Chemistry and Physics Teachers.

President, S. E. Coleman, High School, Oakland, Cal.
Vice-President, James McIntosh, High School, Stockton, Cal.
Secretary-Treasurer, Edward Booth, Dept. of Chemistry, University of California.

National Educational Association.

President, William H. Maxwell, Supt. of Schools, New York City.
First Vice-President, John W. Cook, Prin. State Normal School, DeKalb, Ill.
Treasurer, James W. Crabtree, Peru, Neb.
Secretary, Irwin Shepard, Winona, Minn.

Association of Teachers of Mathematics in the Middle States and Maryland.

President, David Eugene Smith, Teachers' College, Columbia University, New York City.
Vice-President, H. B. Fine, Princeton University, Princeton, N. J.
Secretary, Arthur Schultze, High School of Commerce, 4 W. 91st St., New York City.

Physical Science Section, Nebraska State Teachers' Association.

President, Herbert Brownell, State Normal School, Peru.
Secretary, D. A. Sentes, Omaha High School, Omaha.

Mathematical Association of Washington.

President, Rose M. Dovell, Walla Walla.
Vice-President, E. Morritz, State University, Seattle.
Secretary-Treasurer, Zella E. Bisbee, North Yakima.

REPORT OF THE FEBRUARY MEETING OF THE NORTH-EASTERN OHIO CENTER OF THE C. A. S. M. T.

This was one of the most helpful and interesting science and mathematics meetings ever held by this or any other association. Over sixty teachers from this part of Ohio were present. The program was carried out in full as printed. The laboratories of East High School were inspected Saturday morning, February 11. Luncheon was served at University School and a considerable time before and after luncheon was spent in inspecting the apparatus which was on exhibition. This feature of the meeting proved to be one of the most interesting on the program. The early part of the afternoon was spent among the laboratories of Central High School. At 3 o'clock the balance of the program was given in the library, after which a party of forty visited the mammoth power plant of the Cleveland Electric Railway. During the morning session it was voted to consolidate with the Ohio Association, at the same time retaining membership in the Central Association. A number of new members were added. It can be safely said that the North-Eastern Ohio Center is no longer an experiment.